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ABSTRACT

THA-MASTER is a model program for the training of teachers from other disciplines and/or grade levels as secondary school teachers of mathematics and physics. The program for each discipline includes brief refresher courses which include content courses, workshops, and laboratories. Methods are presented as an integral part of each course. THA-MASTER has been offered at eight university sites and two school districts and a chemistry model has been developed. The document includes a summary of the program, evaluation reports from 1983-1987, a report from the dissemination conference, and final site reports. The final site reports included were from Arizona State University; Beaver College; Northern Colorado University; Portland, Maine Public Schools; Texas Woman's University; Trenton State College; and Western Oregon State College. (CW)

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THA-MASTER, The Hellman Academy for Mathematics and Science Teacher Education Retraining

Long Island University
Brooklyn Campus
Institute for the Advancement of Mathematics and Science
1 University Plaza
Brooklyn, NY 11201

Grant No.:

G008302354

Project Dates:

Starting Date: September 1, 1983
Ending Date: July 31, 1987
Number of months: 47

Project Director:

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Fund Program Officer (s): Hilda Moskowitz
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Grant Award:

Year 1	$99,816
Year 2	$124,027
Year 3	$142,998
Year 4	No cost
Total	$366,841

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SUMMARIES

1. Paragraph Summary

THA-MASTER is a model program for the training of teachers from other disciplines and/or other grade levels as secondary school teachers of mathematics and physics. The program for each discipline includes brief refresher courses; especially designed content courses given in discrete time blocks and workshops and laboratories. Methods are presented as in integral part of each course. THA-MASTER has been offered at eight university sites and two school districts and a chemistry model has been developed within the last year. THA-MASTER model creates a mechanism for dealing with teacher shortage/teacher surplus on a regular basis; provides horizontal career opportunities for teachers; attracts women and minoritites; encourages cooperation among universities and school systems; and helps universities revitalize their own programs and curriculum by creating a new flow of students. It is cost effective and has led directly to new grants and awards for thos universities involved.

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THA-MASTER, The Hellman Academy for Mathematics and Science Teacher Education Retraining

B.1 Executive Summary

THA-MASTER, The Hellman Academy for Mathematics and Science Teacher Education Retraining

A. Project Overview

A critical nationwide need for teachers of mathematics and science has existed in this country for a variety of reasons. In 1975-1976 the situation became intolerable when the nation's largest school system, that of New York City, utilized massive layoffs and excessing as a means of resolving its fiscal crisis. Seed money from the National Science Foundation enabled the Brooklyn Campus of Long Island University to develop a small scale realistic retraining program for teachers of mathematics. Support from the Fund for the Improvement of Postsecondary Education has made possible the extension of this project to include science. It has also enabled its dissemination to universities and school districts across the country. An EESA Title II grant supplemented FIPSE aid by providing stipends to participants. In an important sense, THA-MASTER program proved to be one of the earliest cooperative ventures between the NSF and FIPSE.

B. Purpose

THA-MASTER empowers institutions of postsecondary education to meet the needs of local school systems through the retraining of science and mathematics staffs. It disseminates its new curriculum model to universities and colleges across the United States. The network it develops enables THA-MASTER initiatives to continue following the conclusion of the funding period.

C. Background and Origins

In the mid-1970's, when the New York City Board of Education laid off and excessed thousands of teachers in response to the City's fiscal crisis, adherence to contractual obligations caused firings of staffs by seniority rather than by certification. There arose a need to retrain teachers in disciplines other than mathematics and science so that they could fill vacancies in these critical areas. What was needed was a program acceptable both to mathematicians and to educators and manageable for teachers. The program would have to approximate the content of the traditional mathematics major but yet take into account the needs and backgrounds of classroom teachers as well as the requirements for state certification and city licensure, when appropriate. The first planning group included representatives of the

University, New York State Education Department, New York City Board of Education and post secondary mathematics educators. Subsequently, the planning group has been expanded to include faculties from New Jersey to Oregon.

D. Project Description

Experienced teachers who were not mathematics or science undergraduate majors are offered a series of graduate courses designed cooperatively by university faculty, teachers, supervisors, state education officials and consultants. The curriculum assumes little or no prior knowledge in each subject area. Individual participants needs are met through flexible grouping techniques. The dissemination effort has resulted in the receipt of more than 150 formal inquiries for replication in the two year period of August, 1983 through August, 1985. As the result of the FIPSE grant, funding has been awarded by Long Island University to Beaver College, The University of Miami, Arizona State University, Trenton State College, Texas Woman's University, University of Northern Colorado and Western Oregon State College.

E. Project Results

A formal evaluator was hired to design and conduct the evaluation. An overwhelming 92 percent of the participants stated they planned to teach mathematics as a result of THA-MASTER. More than 80 percent of the initial group secured mathematics licenses from the New York City Board of Education. THA-MASTER students do well when compared with regularly trained teachers and substantially better than those recertified outside of this program. Courses were evaluated very positively by participants with "A", by far, the most typical rating of all courses in the program. There were no "D" or "F" ratings and only two isolated ratings of "C".

Dissemination Sites

The local project directors were unanimous in their support of the project and of the quality of assistance received from the founding site. The majority of the sites have continued to work with the Institute for the Advancement of Mathematics and Science at L.I.U. And, among them, the sites have raised in excess of a half million dollars to continue the efforts started under FIPSE funding. Great interest has been shown by universities and school systems of Puerto Rico partially as a result of the San Juan Conference of 1986.

F. Summary and Conclusions

The THA-MASTER program is an effective economical approach for the recruitment and retraining of teachers in the critical areas of mathematics and science. It is an appropriate approach for rural, urban and suburban areas as well as for special interest groups wishing to provide quality education for all pupils. FIPSE funding permitted us to develop a model for inter-university cooperation as well as for the evolutionary development of cooperative efforts among faculty of education and arts and sciences faculties, universities and school districts and state education departments. As an example, the Portland Public Schools, in Portland, Maine initially brought together Maine State Education officials and THA-MASTER directors to consider the feasibility of implementing THA-MASTER in Portland. The successful initial meeting resulted in THA-MASTER being funded by Portland and an ultimate change in Maine's certification regulations.

FINAL REPORT

THA-MASTER, The Hellman Academy for Mathematics and Science Teacher Eduaction Retraining.

Long Island University, Brooklyn Campus
University Plaza
Brooklyn, New York 11201

Madeleine J. Long, Ed.D.
(718) 403-1056

A Project Overview

The Hellman Academy was developed in response to a critical nationwide need for mathematics and science teachers. New York City typified the problem in 1975-1976 when urban fiscal difficulties resulted in teacher excessing and lay-offs in most educational areas, coupled with severe shortages of secondary school mathematics and physical science teachers. The mathematics model was initiated and developed at The Brooklyn Campus of Long Island University with grants from the National Science Foundation from 1977-1981. It has continued with support from the Fund for the Improvement of Postsecondary Education since 1983. It is housed at the Institute for the Advancement of Mathematics and Science at The Brooklyn Campus of Long Island University and is also offered at universities and school districts across the country. The formal project culminated with a Dissemination Conference held in San Juan, Puerto Rico and co-sponsored by Inter American University and Long Island University.

B. Purpose

The major purposes of THA-MASTER include:

* Continuation and improvement of the project at Long Island University.
* Development of science models similar to the mathematics model.

* Dissemination of science and mathematics models to universities and colleges across the United States.
* Development of a network of universities, colleges, state education departments and local school districts to continue THA-MASTER initiatives at the conclusion of the funding period.
* Creation of a new curriculum model which distinguishes, theoretically and practically, between professional mathematicians and scientists and secondary school teachers.

C. Background and Origins

The Board of Education of the City of New York signaled the need for a specific retraining program in the mid-1970's when it laid off thousands of teachers and simultaneously announced a critical shortage of mathematics and physical science teachers. The largest school system in the United States had announced its intention to give first priority for job openings to its own laid off teachers rather than seek new recruits formally and traditionally trained in mathematics. Clearly the Board was interested in retaining experienced teachers -- although there was no initial evidence to suggest that it was searching for the most able or best qualified from among those who had been laid off.

Faced with the inevitability of the Board's decision, the challenge was to create a program acceptable to mathematicians and educators and manageable for teachers. The first attempt was aimed at developing a program which would approximate the formal study of a mathematics major, while taking account of state certification requirements, the unique learning styles of adult learners, and the particular backgrounds and needs of classroom teachers.

The very first planning group involved a university mathematics

chairman, the director of the Education Division, an Arts and Sciences dean who was also a physicist, a high school assistant principal for mathematics, the Chief of the Bureau of Mathematics Education and the Bureau Chief of Teacher Education, NYSED, the New York City Board of Education's Executive Personnel Director and Dr. Morris Kline, Professor Emeritus at New York University's Courant Institute of Mathematics Sciences. In the ten year period since THA-MASTER's inception, mathematics faculty from New Jersey to Oregon have been added to the planning group.

The National Science Foundation funded the mathematics retraining program in its early years, while the Fund for the Improvement of Postsecondary Education provided the funds to improve and extend the original efforts, create a science model and test both the science and mathematics models at different sites. In an important sense this program proved to be one of the earliest cooperative ventures between the NSF and FIPSE.

D. Project Description

The mathematics model has been offered at Arizona State University, Beaver College, the University of Miami, Texas Woman's College, Trenton State College and Western Oregon State College. The school district of Portland, Maine and the Great Neck Unified School System on Long Island have also adopted the mathematics model. The physics model was offered at the University of Northern Colorado. With the exception of one university, all projects are housed in mathematics or physics departments. Subsequent to the funding period a chemistry model has been developed at Long Island University.

The features which define THA-MASTER and make its curriculum unique include:

* a series of graduate courses cooperatively designed by university faculty, teachers, supervisors, state education officials and consultants for experienced teachers who were not mathematics or science majors as undergraduates.
* refresher courses which prepare students for mathematics or physical science programs and begin with an historical introducation to these disciplines as well as with consideration of their nature and aims. They proceed to review essential topics from conceptual and practical standpoints.
* a three-tiered screening procdure for all candidates which involves a special application form, an individual interview and successful completion of the refresher course.
* a curriculum which assumes little or no prior knowledge and proceeds from the study of

  Mathematics: elementary algebra, geometry and trigonometry, through differential and integral calculus, to a sophisticated course whose topics include number theory, logic, probability, projective geometry, and topology.

  Physics: classical areas of mechanics, heat, sound, light, and electricity to modern physics.
* the structures of the courses take account of the natural building block structure of the disciplines. They are sequential and modular and require mastery at each stage.
* small workshop/recitation sessions for each lecture session where participants are grouped and regrouped in accordance with performance. Sessions are taught jointly by mathematics/science

educators from local secondary schools and university mathematicians and scientists.

* a fundamental philosophical and pragmatic distinction between the preparation of the future teacher of secondary school mathematics and physics and the traditional major most interested in research and/or university teaching.

The dissemination function of THA-MASTER was its newest and, perhaps, most exciting component. FIPSE provided funds which L.I.U. awarded to a limited number of colleges and universities that wished to participate in the program and demonstrated the capability to do so. In a two-year period, from August, 1983 through August, 1985, more than 150 formal inquiries were received from all regions of the United States and Canada. And inquiries continue to arrive. THA-MASTER method of funding appealed to colleges, universities and school districts interested in performing a community service, willing to commit their own funds to important projects and eager to become involved with a nationwide network of mathematicians, physicists and educators who possess similar interests and motivation. The interest in THA-MASTER has been so great that in some instance State Education Departments have helped fund the project at local universities; in others, universities attempt to secure funds from the Economic Security Act so that they can join the Network.

PURPOSE OF THA-MASTER NETWORK CONFERENCE

The THA-MASTER Network Conference was held in San Juan, Puerto Rico from December 3-6, 1986. It was held in Puerto Rico in order to continue the dissemination efforts at different sites in the United States and to explore the possibilities of developing a bilingual component. The

conference was attended by personnel from Long Island University, directors and teacher participants at the various sites, guest speakers, and visitors from the educational community in Puerto Rico.[1]

E. Project Results[2]

Evaluation at LIU

To evaluate the project, data were gathered from a variety of sources: pre- and post-tests of content and attitudes, interviews with project staff, interviews with former students and monitoring of project activities. The pre-test of attitudes and demographic items was designed to collect basic data, to elicit self-concepts of ability in the subject areas and to determine students' evaluation of faculty, their experiences in the program and at the University. The post-test, designed so that comparisons could be made on a number of items, also contained a section in which students were asked to give an overall evaluation of each course they took. Students were also pre- and post-tested in the content areas with tests developed by the project faculty. Pertinent findings include the following:

* Students exhibit a large degree of variation on all status characteristics. Ages ranged from 23 to 61. Approximately 25% majored in elementary education as undergraduates; 25% in science; and 30% in social science. Smaller groups majored in such areas as speech or English. Most had studied beyond the master's level.

1. See Appendix IV for Conference Proceeding's
2. See Appendices I,II and II for Evaluation Reports.

* The factor selected most frequently as a reason for appyling to the program was the desire to teach mathematics and the appeal of the relatively short time span required to complete the program.
* An overwhelming 92% of the students said they plan to be teaching mathematics as a result of THA-MASTER. Many of these students plan to continue graduate studies in mathematics.
* Courses were evaluated very positively, with "A," by far, the most typical rating of all courses in the program. Ther were no D or F ratings and only two isolated ratings of C.
* The opportunity to study with other adults in courses especially designed and structured for this audience was regarded as essential. Participants paid tuition when they could have retrained at other institutions free of charge.
* A major criterion of the program's success is the number of retrained teachers who become certified to teach mathematics. More than 80% of the initial group have been licensed in this area through the New York City Board of Education.

Dissemination Sites

Reports from the various dissemination sites have revealed interesting information and results, including the following:

* Local project directors were unanimous in their support of the project generally and, specifically, of the quality of assistance they received from the founding site. One local director said, "I can get on the phone ar any time and get answers."
* Directors report being pleased with the faculty teaching the courses. The syllabi, originally developed at the Long Island University project, were very helpful.

* Departments of Education and Mathematics have become closer than they previously were at many of the sites.
* Plans have been made to institutionalize the program at a number of sites.
* One site received approximately $200,000 in state funds to continue the program started by THA-MASTER.
* Two of the project courses are being offered to schoolteachers in the Philadephia School System. The local director points to the fact that Philadephia's support, in the form of state funding to pay for the courses, is a tribute to the "good press" the Long Island University model program has had in the area.
* Local project directors feel they have a support system and network which has emerged from their formal and informal meetings and plan to keep it active.
* Strategies are now being developed to establish new levels of collaboration between universities and school districts.
* Constant contact indicates that THA-MASTER students do well when compared with regularly trained teachers and substantially better than those recertified without benefit of this program.[1]

Perhaps most significant, the majority of the sites have continued to work with the Institute for the Advancement of Mathematics and Science at LIU on new mathematics and science initiatives. Finally, the project director has been asked to speak about THA-MASTER at more than forty national and regional meetings.

1. See Appendix IV for Site Reports

F. Summary and Conclusions

Retraining programs, particularly those which aim at developing expertise from other disciplines, have emerged as one of the more effective strategies for dealing with the teacher crisis. Those of us who have been involved in THA-MASTER since the mid-seventies are not surprised. What has interested us is the relative ease of adapting this particular model to new settings, its applicability to both school systems and universities, and its cost-effectiveness. The acceptance of the model and its courses as an alternate route for preparing teachers has been gratifying. The chairperson of the Mathematics Department at one participating university has said that THA-MASTER "is more effective than the traditional Secondary Education/Mathematics MAster's Degree Program." One state adopted the curriculum "wholesale" as its alternative certification route. Mathematics examiners claim there is no discernible difference when THA-MASTER graduates are compared, vis-a-vis written examinations, with traditional mathematics majors. Some graduates obtain mathematics positions in special high schools for the gifted...and so on.

Positive results which have thus far ensued from THA-MASTER include: recruitment, training and placement of new mathematics and science teachers; establishment of a nationwide network of faculty addressing a critical problem; involvement of mathematics and science departments in an area many have historically been unwilling to enter; a growing cooperative effort between schools of education and mathematics and science departments; a willingness to reorder and restructure basic content; and an emergence of the usefulness and adaptability of the program's design and content for significant numbers of minorities

including women, Blacks, Native Americans, and Hispanics.

THA-MASTER has an established and operative network and a program which has worked over time in many diverse settings. Because it is flexible and adaptable, it is a particularly useful model for implementation in the fifty states. In many states, funds availabe under the Education for Economics Security Act can be used to support the implementation of THA-MASTER. In fact, five such awards for programs based upon THA-MASTER have already been made.

As a direct result of THA-MASTER, Long Island University created and institutionalized the Institute for the Advancement of Mathematics and Science. The Institute is a part of the University College of Arts and Sciences and is now responsible for a large number of special mathematics and science programs. It works directly with a large array of urban and suburban school districts and organizations like The Urban Coalition. Most recently, a retired Superintendent has joined its staff as Associate Director.

Services Provided by THA-MASTER

THA-MASTER can provide information and services to all interested parties who wish to become further acquainted with and involved in its unique program, including rural, urban, suburban and special interest groups wishing to further the educational excellence of their communities. Services of interest include:

* course descriptions and course design
* dissemination techniques
* evaluation materials
* networking
* speakers and consultants

* strategies for dealing with adult learners

* technical assistance and staff development

* videotapes

**

APPENDIX I

EVALUATION REPORT

1983-1984

**

EVALUATION REPORT

THE HELLMAN ACADEMY FOR MATHEMATICS AND MATHEMATICS AND SCIENCE TEACHER EDUCATION RETRAINING

Supported by

The Fund for the Improvement of Postsecondary Education

1983-84

Dr. Carole Kazlow

December 1, 1984

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PROGRAM DESCRIPTION

The main objective of this program is to retrain experienced teachers in the discipline of mathematics, to develop a similar program for physics, and to disseminate the programs to other universities. The programs are generall ··one-year plus summers, non-traditional, university-based. The mathematics program at the original site was maintained while the physics model was developed and initiated. Both models were developed as a reaction to the nationwide shortage of math and science teachers and are believed to be highly generalizable models which can be replicated and disseminated to sites throughout the country.

The structure of the program, regardless of subject, is to begin with a refresher course during the summer. This course is to be followed by a sequence of five specially developed eight-week courses in mathematics or physics. Each student can earn 15 graduate credits upon successfully completing the program.

During each of the eight-week modules, students meet twice. One session consists of a four-hour lecture, and the other, a four-hour workshop designed to enable students to review problems with an instructor. The workshop reinforces, reviews, and at times, extends lecture materials and introduces other topics, the need for which arises in the course of the program.

The second major program objective of Year One is to select two regional sites in order to disseminate the mathematics program in the second year of the grant.

EVALUATION, DESIGN AND OBJECTIVES

This evaluation was designed to address the two major foci, training and dissemination, of the Hellman Academy for Mathematics and Science Teacher Education Retraining (THA-MASTER) project funded by the Fund for the Improvement of Post-Secondary Education for the 1983-86 project period. The project involves the adoption, implementation and adaption of a teacher training model which consists of a series of specially designed graduate-level courses in the subject area (mathematics and physics) and a dissemination process. The dissemination process includes the selection of regional and national university sites; selection and training of core faculty; recruitment and selection of trainees; and conduction of awareness sessions for faculty, supervisors and school personnel.

Training Evaluation

In order to evaluate this component of the project, data were gathered from a variety of sources: pre- and post-tests of content and attitudes, interviews with project staff and students, a monitoring of project activities and classroom observations by project personnel.

The pretest of attitudes and demographic items (See Appendix 2), designed by the evaluator, was administered in the fall and the post-test was given in June. A code was

developed so that pre- and post-tests could be matched without respondents revealing their names. This survey instrument was designed to collect basic demographic data, to elicit self-concept of ability in the subject area, to determine students' evaluations of their faculty and their experiences in the program, as well as their experiences at the university generally. The post-test was designed so that comparisons could be made on a number of items. In addition, the post-test contained a section in which students were asked to give an overall evaluation of each course they took by assigning a grade from A to F to the particular course.

Students were also pre- and post-tested in the content areas with tests developed by project faculty. Informal interviews of students were conducted by the evaluator one week after the post-tests were completed and again in December, several months after the students had completed the program. Faculty members were interviewed in order to obtain any suggestions they might have for change. During the spring semester a faculty member made 18 classroom visits to observe project teachers in their classrooms. Each of the 9 teachers who are currently teaching mathematics without being licensed or certified to teach the subject was observed twice in order to see if higher exposure to the program had resulted in improving ability to teach mathematics.

Dissemination

According to the proposal, two sites were to be selected for dissemination during the second project year. Contacts were made with universities all over the country. The project director visited 12 potential sites, including the University of Pennsylvania, the University of California, Davis, the University of Kentucky, the University of Miami and the University of Puerto Rico. Two university sites were selected: the University of Kentucky and the University of Miami, and a third site is to operate in a school district in Great Neck, New York. Both the University of Miami and the University of Kentucky have sleected a core group of students and faculty and have begun to implement the program at their sites.

Subsequently, the program implementation was broadened to include Beaver College. The Beaver College site was made possible as a replacement for the physics site at L.I.U. A site is also being developed in Portland, Maine.

RESULTS

Interviews

The program started late in 1983. It commenced in late September rather than in the summer as planned. In order to meet the objectives of the grant, many activities were undertaken prior to its formal inception by the project staff. In the spring and summer preceding initiation, staff recruitment and training was completed as scheduled. A physics model and curriculum was developed. Students were recruited, applications reviewed and interviews were conducted. One hundred and forty-six student inquiries were made and 93 students submitted applications. Of these, 39 students were accepted in mathematics and 14 in physics. Thirty-one math students and 11 physics students started the program. After the refresher course and the initial course (Math or Physics 501) were completed, 29 math students and 7 physics students remained. By the end of the project year there were 24 math students and 6 physics students.

A sample of students and faculty were interviewed by the evaluator. The fact that the program started late was a major problem, according to students and faculty. Students had to take the refresher course in September and October and begin the regular courses immediately thereafter. This did not

leave time for students to review their work and overcome any problems that were uncovered. One faculty member and some students felt that four hours of lecture is too long a stretch for many students, especially those that have spent a full day at work. Others expressed satisfaction with the format. Lecture time could be divided into two days or, alternatively, Saturday morning lectures might be an option to consider within the current structure if individual project personnel prefer a different format.

Students were unanimous in their praise of the faculty and the administrator. They described the teachers as "fantastic." One student expressed the feelings of the group when she said, "I learned a great deal. These teachers are really able to teach!" Another said, "I liked being pushed to the limits of my ability and beyond." The students liked the interaction that existed between faculty and students. They praised the faculty's emphasis on the development of comprehension. Furthermore, the enthusiasm of the faculty and their patience were noted repeatedly. Despite the overwhelming praise of the faculty and the program, most students found the pace grueling. They felt they needed more time to absorb the amount and type of material presented. Although students are made aware at the very beginning that the time commitment is extensive, this should be reinforced extensively.

Based on these interviews, it can be stated unequivocally

that the project director and her staff developed a cohesive group of faculty and students and created a postive climate which supported the difficult task which is being attempted. Mathematics and physics are among the most demanding disciplines. That the students were so positive about their experience, despite the pace-related pressures that they felt and the difficulty of the content, says much for the administrator of the grant.

Of the 24 students who completed the mathematics component of the program, seventeen were interviewed again in December of 1984. The purpose of this second interview was to gather information concerning participants' attitudes towards the program, the degree to which the program prepared students to take the New York City licencing examination, pass it and be placed in teaching positions, as well as students recommendations for improving the program.

The evaluator conducted the interviewes using an interview guide which consists of open and closed ended items.

Participants were first asked to think back to their initial expectations in order to determine whether the program met these expectations, exceeded their expectations or failed to meet their expectations. Of the seventeen responses, ten felt their expectations had been met, four said the program exceeded their expectations, and three said the program failed to meet their expectations. Respondents whose expectations were exceeded were then asked to explain their choice. One student said he.."had no idea what I was in store for. I use math now in almost every aspect of my

life. I look at the world in a different way, in a more mathematical way." This student described how he teaches music with an emphasis on mathematics, and claims it has made him a better teacher generally. Another student described how, as an English teacher, his mathematics has helped him. He gave an example of how he has applied mathematical concepts to the teaching of literature, e.g. Poes' Goldbug, and how his students enjoy the way mathematics is integrated into the teaching of literature. Another interesting example of how a student has applied his mathematics came from a teacher of driver education who now uses a mathematics approach. "The caluclus is beautiful. I've used it in a hyperbolic decline chart in driver education."[1]

All of the respondents, at some point in their interview, said the teachers were outstanding. There was not a single negative or even neurtal evaluation of the faculty. The participants described the faculty as "fabulous" "patient" "knowledgable" and "outstanding!"

Those few students whose expectation were not met referred to problems of having too much to do in too short a time. They felt that they had not been prepared to deal with such an intense and time consuming experience. Even in these cases, however, the faculty and the program overall were praised. Any problems mentioned were directed toward the students themselves.

One major criterion of program success is the number of teachers who become licensed and/or certified to teach mathematics (science), are placed in appropiate positions, succeed in those positions and who demonstrate a commitment

1 These teachers are awaiting the results of the mathematics license examinat

to the profession. Respondents were asked if they took the New York City examination, which was given in September, 1984 and whether they passed. Fifteen of the seventeen have taken the test. However, they have not yet received the results. The students who have not taken the exam yet plan to take it when they complete an additional six credits of mathematics. Many (13) of the students have already continued taking graduate courses in mathematics and many are currently enrolled in a Master of Science in Education degree with a specialization in mathematics at L.I.U.

When the students were asked to share their thoughts about the program, their responses pointed to several potential recommendations for change. The most frequently mentioned concern was that the program was timed in such a way that students felt a great deal of pressure. Several students suggested expanding the scope of the program to 18 months. Another concern was with the four-hour lecture.[1] One suggestion was to have a two-hour lecture followed by a two-hour workshop on each of the days classes meet. Several students felt they would like to see more about computers included in the scope of the courses. Also students felt well prepared in calculus but some felt they needed more time with geometry and trigonometry. This was especially true for students whose mathematics background at the pre-college level was weak.

1 Students at the Great Neck site claim "time flies" during the four-hour lecture (with many of the same instructors.)

Many of these suggestions are currently under consideration and have already been incorporated into site dissemination programs. At Brooklyn it is likely that Mathematics 501 will be expanded to a two-semester course. Adaptations which touch upon the length of the program and the level of the courses (undergraduate) would not alter the nature of the program. As one student said, "There were a lot of wonderful things being taught, a lot of knowledge available." The project has succeded in making this knowledge accessible.

Questionaires

Twenty-four matched pre- and post-tests were subjected to data analysis. Using the Statistical Package for the Social Sciences (SPSSX), frequency counts on all variables were obtained for the total sample. In addition, a series of *t* tests for paired samples were computed for the total sample and for males and females separately.

This group of students varied on many dimensions. The 11 male and 13 female students[1] ranged in age from 24 to 55, with 12 students in their 30's. Their undergraduate academic backgrounds were also diverse. Four students were elementary education majors, three majored in either history or biology, two were either psychology or economics majors, and there was one major in each of the following: chemistry, English, art, mathematics, sociology, anthropology, political science and home economics. About 60% hold the B.A.

1 Physics and Mathematics

degree as their terminal degree. The others have master's degrees Their appraisal of the quality of their own undergraduate work was "average" (N = 12) or "above average" (N = 11). Only one said his/her work was below average. More than half (n = 14) received their degrees from the City University of New York, with the others divided among several state and private colleges.

Nineteen of the 24 students are currently teaching. All have taught from 1 to 26 years, with about half the subjects reporting that they have been teaching at more than 5 years. Most of the students are teaching at the secondary level, with 9 at the junior high school or intermediate level and 8 at the high school level. Only 3 are currently teaching in an elementary school. These students teach a wide variety of subjects with the greatest number (N = 9) teaching mathematics, although none are state certified or licensed. Eighteen of the students were in the mathematics component and six in the physics component of the program.

When asked to check their reasons for applying to this program (see Table 1), the factor selected most frequently was long-term desire to teach mathematics or physics, followed by the appeal of the relatively short time span required to complete the program. Only 8 of the 24 students said they would be going to graduate school for training in mathematics or physics without this special program.

Respondents were asked if they would take the New York City licensing examination in mathematics or science if it were offered soon after their completion of the program. Most (N = 19) said they would, three said they would not, and three said they did not know. Of the three who said they would not take the test, two said they were afraid to take it and one felt unprepared. More than half (N = 14) plan to continue graduate work in mathematics and physics upon completion of the program.

The final section of the post-test consisted of a listing of the courses in the program. Students were invited to evaluate each course by checking the letter grade from A to F that came closest to describing their overall evaluation of the courses. (See Table 2). The courses were evaluated very positively by the students with "A" being the modal rating. Most courses were rated either "A" or "B" with very few "Cs," "Ds," or "Fs."

Another comparison (Tables 3 and 4) was made between a number of items which appeared on both the pre- and post-tests. Twelve aspects of the program or services offered by the university were rated on a scale of "1" to "5" by the students. A rating of 1 represents "very satisfied," 2 means "somewhat satisfied," 3 is a neutral response and 4 and 5 represent "somewhat" to "very dissatisfied." Table 3 compares frequencies of ratings on each item for the

pre- and post-tests. This table shows an initially high rating of several important elements of the program. Among the highly rated items were those that referred to faculty attitude and faculty teaching ability, closely followed by the high ratings given to the educational philosophy of the program. That these high ratings do not reflect yea-saying is demonstrated by the much lower ratings of the parking and dining facilities and other nonacademic services at the university.

A series of t tests for correlated means (Table 4) was generated yielding nonsignificant results on virtually every one of the program-specific items. This group of students did not change their initially high evaluation of the components of the program or their lower evaluations of the other experiences they had this year at the university.

Finally, self-concept items were assessed. Table 5 consists of a comparison of self-assessments of ability to study or teach physics or mathematics. Students were somewhat more confident of their ability to study and teach at the time of the posttest, but the differences were not statisically significant. (See Table 6)

Classroom Observations

Because nine of the students in the program were already teaching math, the project director and evaluator

decided to have these teachers observed in order to begin to see if there is observable change in teaching behavior which can be associated with participation in the program. The observer, a faculty member with experience teaching secondary level mathematics, made two rounds of visits in November and May. Nine teachers were observed the first time and eight the second. The observer remained in the classroom for an entire class period. Using a project developed rating scale (Appendix 3), each teacher was rated on the same set of behaviors.

Although the reliability of the observations is somewhat problematic given the fact that there was only one observer, and the number of observations limited, the findings suggest that with some refinements teacher observation may be a very valuable component of future evaluations. Table 7 compares frequencies of an array of behaviors in November and May. The reader can review the table by reading from left to right, comparing the frequency of ratings to determine specific changes or by comparing totals in the various categories from "1," or excellent, to "5" to see a general change. Table 7 consists of 15 items which were included to rate mathematics teaching effectiveness in the classroom. The other components of the scale are not reported in this paper because of the weak relationship between the items and the major objectives of the program.

The observations indicate an overall improvement between the two visits. There were many more "needs improvement" ratings and fewer "goods" on the first observation. This seems to indicate that there is carryover from the cognitive to the behavioral domain in the classroom!

Content Tests

Content tests were developed in both mathematics and physics and were administered on a pre-post basis. Pre-tests were given in November. The post-test was given at the conclusion of the final course. The degree of reliability and validity of the instruments was not determined. Indeed, there are several problems with program developed measures of this type when used to evaluate the effectiveness of a program. Since there is no comparison (control) group, one cannot generally determine the degree to which knowledge is program related. However, in this case, it is unlikely that students would have had exposure to information on knowledge of this type had they not been exposed to the program.

In addition, when a test is used as a pre-test there is the problem of sensitization. Again, this is not viewed as problematic in this instance because the program is designed to train non-mathematics (science) teachers in math or science and if the pre-test motivates students to acquire appropiate knowledge, so be it. Table 8 shows that

there was growth for both mathematics and science students. In addition, all students who successfully completed the program had to pass all of the courses. This is another important indicant of attainment of knowledge in the content areas.

RECOMMENDATIONS

1. Alternative structural arrangements should be studied. It might be advantageous to divide the lecture into two components rather than have students take one four-hour lecture. At some sites, where the recertification time press is not so great, a two-year sequence could be followed.

2. The observation component of the formative evaluation should be expanded. There should be more than one observer and an increased number of site visits. This is planned for the second year when students are teaching in license.

CONCLUSIONS

The objectives of the program as specified in the grant were accomplished. Students did well, gained confidence, and these changes seem to have carried over to their teaching. The model appears to offer great promise in the area of teacher education nationally.

Dissemination sites have been selected, and progress is ahead of schedule. The project director has enhanced the image of the project and helped to diffuse the training concept through papers written or presented this year as well as the visits she has made to potential sites and state departments of education.

**

APPENDIX II

EVALUATION REPORT

1984-1985

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EVALUATION REPORT

THE HELLMAN ACADEMY FOR MATHEMATICS AND SCIENCE TEACHER EDUCATION RETRAINING

Funded by

The Comprehensive Program Fund for the
Improvement of Post Secondary Education

1984-85

Dr. Carole Kazlow

September, 1985

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PROGRAM DESCRIPTION

This is the second year of a three year grant designed to retrain experienced teachers in the discipline of mathematics. The model, developed at Long Island University, represents a structural innovation in teacher training. Students at Long Island Uneversity begin with a month long refresher course during the summer. The courses have been designed with the needs of the targeted population in mind. Many of the targeted students have little formal training in mathematics.

During 1984-85 changes were made in the time alloted to each course and each session as a consequence of the experience acquired during the first year. Each course was extended from seven to ten weeks. The number of hours was decreased from four to two on each of the two nights the courses meet.

EVALUATION, DESIGN AND OBJECTIVES

The two major focuii of the project during the second year project are training and dissemination. Therefore, this evaluation will address these two issues. According to the original proposal the mathematics and science program was to be replicated at the Long Island University site during the second year. However, the physics component was discontinued and an additional dissemination site was added. The plan was originally to disseminate the model to two Regional Sites. In addition two more sites, referred to as National Sites, were to be selected from universities located in Federal Regions V-X.

TRAINING EVALUATION

In order to evaluate this component of the project, data were gathered from a variety of sources: pre-and post-tests of content and attitudes, interviews with project staff, interviews with former FIPSE students, and a monitoring of project activities.

The pre-test of attitudes and demographic items, (see Appendix) designed by the evaluator, was administered in September and the post-test was given in June. A code was developed so that these pre and post-tests could be matched without respondents revealing their names. This survey instrument was designed to collect basic demographic data, to elicit self- concept of ability in the subject area, to determine students' evaluations of faculty, and their experiences in the program, as well as their experiences at the University generally. The post-test was designed so that comparisons could be made on a number of items. In addition, the post-test contained a section in which students were asked to give an overall evaluation of each course they took by assigning grades from A to F to all program courses. Students were also to be pre and post-tested in the content areas with a test developed by project faculty.

DISSEMINATION

According to the initial proposal two sites were to be selected for dissemination during the second project year. Contacts were made and sites selected. The model was adopted by the University of Kentucky, the University of Miami, Beaver College and a suburban school district in Great Neck New York. Project directors at the various sites were in constant communication with the Long Island University project director. The project director visited each site several times during the project year. At these times she observed classes, spoke with students and faculty and had meetings with local project directors, University or College administrators and local personnel. Local project directors were free to call the director at Long Island University for help and did.

Local project directors were required to provide progress reports of their activities. In this way the Long Island University project director was kept up-to-date with regard to site activities. The Long Island University project director also met with local site directors informally several times over the course of the year when attending regional and national conferences.

Before reviewing the adoption process at each site, it is, at this time, appropriate to discuss adaptation in the transfer or dissemination of innovations. In this project, the Long Island University project director functions as a change agent. She has supported the process of local adaptation and modification and believes that such a process insures the acceptance and durability of innovations. At the same time she has accepted the obligation to protest vigorously any modifications in the innovation which, in her estimation, compromise its effectiveness. Based upon this evaluators experiences (with planned change) it is clear that when attempting to disseminate complex innovations, such as this one, a structured, and intensive set of training and monitoring activities is called for. Technichal assistance, in the form of intensive on-site consultations is essential, in addition to the financial support, and printed materials which are traditionally made available. This was well done.

RESULTS

Training: Ouestionnaire

Twelve matched pre and post-tests were subjected to data analysis. Although sixteen students completed the program matched questionnaires were not available for students. Using the statistical package for the social sciences (Spss-x), frequency counts on all variables were obtained for the total sample. In addition, a series of t tests for paired samples were computed.

Of the twelve respondents seven were male and five female. Thirty-eight students applied to the program, twenty-eight were accepted, and sixteen completed. These students exhibited a large degree of variation on all status characteristics. Their ages ranged from twenty-three to sixty-one. Three majored in elementary education as undergraduates; three were science majors; four were social science majors; one majored in speech, and one mathematics. All twelve had studied beyond the master's level The students' rating of their undergraduate work was about evenly distributed between "average" and "above average".

Their teaching experience ranged from one to nineteen years with a mean of nine years. All respondents are currently teaching in the public schools, three at the elementary school level; six at the junior high school level and three in high schools. Three of the twelve were already teaching mathematics when they started the program.

When asked to check their reasons for applying to this program (see table 1), the factor selected most frequently by this group of students was the appeal of the relatively short time span required to complete the program. Only one of the respondents said they would be going to graduate school for mathematics without this special program. Respondents were asked if they had taken the New York City licensing examination in mathematics. One student had already taken the junior high examination and five had taken the senior high test. None had recieved their results at the time the questionnaire was administered. Since the major objective of participating in the program is to prepare to become a teacher of mathematics, and in New York City one must pass a formal licensing examination, to do so, it is important to determine the extent to which students feel prepared to take the examination. Subjects were asked to check the category which describes how prepared they feel. Twenty-five percent of the students responding felt "very well prepared"; 58.3% said they felt "somewhat well prepared"; 16.7% checked "not very well prepared" and none agreed to "not at all prepared". By the time the post-test was administered, half the students were teaching mathematics, four at the junior high and two at the high school level. An overwhelming 91.7% of the students said they "plan to be teaching mathematics next year." Many of these students (50%) plan to continue graduate studies in mathematics 41.7% said they "did not know," and only 8.3% do <u>not</u> plan to continue their studies.

One section of the post-test consisted of a listing of the courses in the program, including the refresher and the workshops. Students were invited to evaluate each course by checking letter grades from A to F that came closest to describing their <u>overall</u> evaluation of each course (see table 2). Courses were evaluated very positively with "A" being by far the most typical rating of all courses in the program. There were no D or F ratings and only two isolated ratings of C.

Comparisons were made (see tables 3 and 4) between items which appeared on both the pre and post-tests. Twelve aspects of the program or services offered by the university were rated on a scale of "1" to "5" by the students. A rating of 1 represents "very satisfied", 2 means "somewhat satisfied", 3 is a neutral response and 4 and 5 represent "somewhat" to "very dissatisfied". Table 3 compares frequencies of ratings on each item for the pre and post-tests. This table shows particularly high ratings for faculty teaching ability and attitude which were maintained throughout the year.

A series of <u>t</u> tests for correlated means (table 4) was generated yielding nonsignificant results on virtually every one of the program specific items. This group of students did not change their initially high evaluation of the program or their lower evaluations of services.

Finally, self-concept of ability in mathematics and teaching were measured. Table 5 demonstrates growth in both these areas. The results for self-confidence of ability in studying were significant at the .05 level.

Content Tests

Content tests were developed by project faculty and were administered at the inception of the program and again after the students had completed all courses.

Both tests consisted of thirty items which were designed to be a reliable reflection of the content domain.

According to the project personnel, the tests are parallel forms. Sixteen students completed both tests. The difference between pre-test scores and post-test was highly significant (See table 7). Despite the lack of a comparison group, we can be fairly confident that his group of students would not have achieved the results they did, had it not been for the program.

Dissemination

The evaluator reviewed all written communications made between local sites and the Long Island University project director. In addition, the Long Island University project director and local project directors were interviewed by the evaluator using an interview schedule which included both closed-ended and open-ended items.

University of Miami

Dr. Gilbert Cuevas is the project director. His role is to coordinate program activities, act as liason with the Dade County public schools (DCPS)and coordinate the recruitment of students with DCPS. Dr. Cuevas developed a flyer describing the project, eligibility requirements for participants and course content and schedules as well as an application form. These materials were made available to prospective applicants. Dr. Cuevas has been actively involved with adapting the program to his setting. One major adaptation or change has been the elimination of a second calculus course. The faculty and students at Miami did not think another calculus course was necessary. They have added more modern mathematics and analysis. The first cycle at this site will be completed this coming June (1986). Changes were made in the schedule and timing of courses to meet the needs of the students.

Nineteen students began the program. At this time only six remain. The reason for the large attrition rate, according to Dr. Cuevas, is that the DCPS system has begun to offer an in-service program which is tuition-free. This program allows teachers to add-on secondary school level mathematics to their certificates. The program consists of a series of workshops covering topics ranging from general mathematics to probability and statistics, including calculus. The program is unique in that participants can obtain teaching credentials in mathematics without having to earn college credit and at no cost to them. The process is administered by the public school system. The major obstacle to retention at Miami is this competing program. Of the seven students that have continued, two are elementary school teachers who want to obtain certification in mathematics and the remaining five are secondary level teachers who want to review or add-on mathematics to their certificates.

In order to overcome recruitment problems, strategies are being discussed to reestablish a level of collaboration between the Miami project and DCPS.

Dr. Cuevas reported being very pleased with the faculty teaching the courses. He also found the Long Island University syllabi which were made available to him to be very helpful. An additional positive outcome which has resulted from their involvement is that the Department of Education and Mathematics have become much closer than they were previously. Dr. Cuevas intends to continue the program. The second class is starting in October. He reported being very satisfied with the assistance he has been receiving from Long Island University.

Beaver College

Dr. Richard Polis, Dean of Graduate Studies, is the Director of the project at Beaver College. Dr. Polis has made several adaptations. Among the admissions requirements is a 3.0 undergraduate average and two courses in mathematics, one of which must be calculus.

Because of these high requirements they have decided not to offer a refresher course. Beaver does not offer the first calculus course. In place of the second calculus course they have developed two selected topics in mathematics: the first course is MA-505, Probability and Statistics, and the second course is MA-510, Euclidean and Non-Euclidean Geometry. Their final course, MA-520 is Introduction to Modern Mathematics.

According to Dr. Polis, only eighteen applied to the program because of limited lead time. Seventeen were admitted. Two dropped because they found the program "too easy". These students had more mathematics in their background than the other students. A third student dropped out because her background was too weak and one student left because of family problems. Thirteen of the original students remain. One new student has been admitted. Eleven of the students are female and three are male. Ten of the students are between 30 and 40 years of age. The remainder are between 40 and 59. Dr. Polis believes the selection process and criteria they have adopted is excellent and is at least partially responsible for the high rate of success of the students at Beaver. He sees the adaptions they have made as enhancing the model and believes it is improtant to require the course in calculus for admission. He is "very satisfied" with the quality of the students and the faculty teaching the courses. Dr. Polis is also very pleased with the services provided by Long Island University. He said, "I can get on the phone at any time and get answers".

The chairman of the mathematics department at Beaver believes that the program may be better than the traditional retraining program they have used in the past. The scheduling of classes has been very flexible. They have not stuck to the traditional calendar but instead worked out the programming with the students. Math 501 was not offered twice a week. Instead they opted to offer it over a sixteen week period because of their belief that the first course that a student takes is crucial. They felt that giving more time to this course would allow them to offer future courses in more compact time frames. MA502 and 503 were offered in the summer. The fourth course MA505 - Selected Topics in Mathematics (Probability and Statistics) is being offered in the Fall. This will be followed by the last two courses, MA510 and MA520 this spring.

In the future, Dr. Polis plans to institutionalize the program as a two year(including summers) sequence.

The studentsat Beaver differ from those at the other sites in one outstanding way. Most are not currently working. Many are certified but are re-entering the profession after a long hiatus. If a student is already certified in Pennsylvania there is no scheduling problem. But if the student needs more than this (in terms of course work) scheduling becomes a problem.

Steps toward the institutionalization of the program have already been taken. Two of the project courses are being offered to school teachers in the Philadelphia public school system. Dr. Polis points to the fact that Philadelphia's support in the form of using state funding to pay for

the courses, is a tribute to the work they have done at Beaver College and the "good press" the Long Island University program has had in the area! Another indicant of institutionalization is that the courses are in the graduate catalogue for 1985-86.

A further example of Beaver's commitment to the program is that Beaver College has reduced the tuition for each of the mathematics courses to $300.00. This means that each student over the course of the program will receive a savings of $765.00. Dr. Polis points to this as an example of institutional commitment to the program.

Dr. Polis is very happy with the program. He has received excellent feed back from a variety of sources. Students are pleased with the quality of the program and the teaching and individual guidance they are receiving. The chairman of Cabrini College wants to implement the program at his school. The school district of Philadelphia, as mentioned earlier, has asked that Beaver offer the cources for their teachers and the Chairman of the Mathematics Department at Beaver is on record as stating "this program is better for training mathematics teachers than our traditional mathematics major program."

University of Kentucky

The University of Kentucky has completed its first cycle. There are no plans for instutionalization at this site. Several obstacles to the successful implementation at the site are apparent. The most outstanding has to do with lack of clarity. Almost from the outset there was a lack of clarity concerning the nature of the innovation. Because of this students were unclear as to what was expected of them as well as what the outcome of the program, especially concerning certification was to be. This lack of clarity spread to the program people as well, who seemed not to understand the essential distinction between the model and a traditional program in mathematics. Therefore, from the point of view of the Long Island project director, the modifications which were made in the program were not acceptable. It is understandable that the adopting organization should want to modify the innovation so it fits into the organization easily. However, the clange agent has an obligation to protest vigorously any modifications in an innovation that are perceived to compromise its effectiveness. The Long Island University project director understands this responsibility and has acted upon it. In this instance, the lack of clarity discussed was exacerbated by a change in project directors early in the program.

Initially, 33 students were accepted. A decision was made to accept all eligible applicants for the refresher and survey of mathematics courses. Twenty-two students completed this sequence. There were 16 women and 6 men. 19 have master's degrees. 10 have elementary certification with the remainder in a variety of secondary fields. The average age of the students is 35 within a range from 23 to 56.

Near the end of summer 1984, the original local project director resigned to accept another position.[1] Professor Stevens of the Department of Curriculum and Instruction assumed the duties of site director. Twenty students (eighteen from the summer workshop and two new students) enrolled in MA502A. Fourteen students completed the course and went on to MA502B. Thirteen students completed MA502B. Reasons for attrition include: conflict with work, pace of classes, frustation related to changes in the program as originally described, perceived discrepencies between program objectives and program classes and frustation over differences between project courses and the number and type of courses required for certification. The thirteen students who completed these did well. Students reported working very hard. As early as the October site visit, Dr. Long and Professor Nicolakis of Long

[1] The problem began with the resignation of the director. The new director was unable or unwilling to deal with the semi-reluctant faculty.

Island University, expressed concern regarding the "traditional nature" of the courses at U.K., the problems related to the pace, and the extreme departure from the model. In addition, the lack of clarity as to certification requirements created unnecessary confusion, frustration and hostility on the part of the students.

The major accomplishment of this project at U.K. is that thirteen students will be certified to teach mathematics in Kentucky.

Great Neck

The Great Neck site differs from the three university sites. There the program is being offered by a suburban public school system to its teachers. The school system has been paying teacher's tuition. This is a very interesting alternative delivery system

Recruitment at the Great Neck site was non-traditional. The University did not screen teachers or request that they intend to teach at the secondary level. All interested applicants were admitted and allowed to go as far as they wished toward the completion of the program. Twenty-two students completed the first course. The faculty expects eight students to complete the total program. It should be noted that this group of students had a variety of objectives, other than certification, which stimulated them to take part in the project.

The Great Neck teachers vary from the traditional university based population. in several other ways as well. All are fully certified for their current positions and tenured. By and large they are satisfied with their teaching assignments. Their main objective for taking the courses had to do with strengthening their understanding of mathematics rather than preparing for a change. According to their instructor, the teachers worked very hard during the summer course (refresher) and in the Fall, when they took the pre-calculus course.[1] A large number of teachers dropped out after the refresher course; despite the fact that most had received final grades of "A". The major reason they gave for discontinuance was heavy work loads. The quality of the work of this group of teachers was exceptional. Many topics were treated in greater depth at the Great Neck site, at the request of the students (teachers). Their instructor was impressed with the level of the students and their ability to undertake this rigorous program. The superintendent of the Great Neck schools attended classes as well and served to inspire the class by setting an example of serious scholarship. According to the instructor, these students would be excellent candidates for teaching.

The experience with this group of primarily elementary school teachers indicates a need for buttressing the level of knowledge of teachers in mathematics at the elementary level.

Disseminating Results

The Long Island University project director has been an active disseminator of information about the project. She has spoken to groups or delivered papers at approximately twelve annual meetings or conferences over the 1984-85 year. In addition she has visited many colleges, universities and local school districts. She has functioned not only as a formal change-agent for each local site, but also as a gate-keeper of information which she has tirelessly shared with all interested parties. Her efforts have enhanced the program immeasurably.

[1] Many of the teachers never intendend to complete the extire course.

Through her efforts, additional funding has been obtained from a New York State Education Department grant (Title II, Education for Economic Security Act). This money is being used to support the grant efforts. It is targetted for student aid, stipends and text-book allowance. The award provides further evidence of the success of this project. Financial backing has also been received from the New Jersey Department of Higher Education to support an additional site, Trenton State College.

Selection of New Sites

The number of new sites selected for 1985-86 exceeds that which was in the original proposal. The mathematics program is being offered for the first time at: Arizona State University; Texas Woman's University; Western Oregon State College; and at Trenton State College. In addition, the Portland public schools are adopting the innovation. The University of Northern Colorado is a site for the Physics model.

The home-site (Long Island University) has accepted a new class and the mathematic's program is being continued at the regional sites (except U.K.) for a second year. This represents a departure from the original proposal. A second departure from the original model is the decision to hold-off on the development of an English model at this time; at the suggestion of FIPSE.

Conclusions

The objectives of the program for the second year, as specified in the grant were for the most part accomplished and in some instances exceeded. The dissemination efforts have been particularly successful. Local project directors were unanimous in their support for the project generally and for the specific, personal quality of the assistance they have received from the Long Island University project director.

At this time the local project directors feel they have a support system or network which has come out of their formal meetings as well as the informal meetings which were held at various conferences. They are hopeful that his network can be institut-ionalized. All dissemination sites have, or will be "graduating" a group of students, (approximately 80) many of whom will be fully certified to teach in their states. The experiences of the second year demonstrate the adaptability of the model in that it has been successfully transferred to new sites. The experience obtained has also pointed to potential obstacles to the successful implementation of a complex innovation. The project director is more aware than ever of the importance of the local project director as an agent of change and the need for clarity on the part of all involved. The project director has continued to enhance the image of the project through her formal and informal diffusion activities.

Recommendations

1. In light of the continued need for teachers in mathematics, alternative sources of financial support for students, should be explored at the local school district, and state levels.

2. If an appropriate norm referenced test is available, it should be adopted. This would overcome the problems associated with attempting to draw conclusions without comparison (control) groups.

3. More time should be given, if possible, to topics in geometry and trigonometry. Students feel least secure in these areas.

4. There is a need for materials (texts) which reflect the content of this program. Perhaps, funding can be sought for such a purpose.

5. The program should be coordinated with a Master's program for those students who wish to continue their studies and earn a degree.

6. It would be functional to institutionalize the "network" which has developed across sites by providing the opportunity for bringing site directors together.

Table 1

Reasons for Attending

Reason	Number Selecting
I needed a change	3
To help me get a job	2
The opportunity to complete a retraining program in a relatively short time appeals to me	5
I always wanted to teach mathematics	3
To help me get a job in a secondary school	4
The tuition is affordable	1

Table 2

Student Rating of Course
(Number, Percent)

	A	B	C	D	F
Mathematics 501	10 (83.3)	2 (16.7)	———	———	———
Mathematics 502	10 (83.3)	2 (16.7)	———	———	———
Mathematics 503	11 (1.7)	1 (8.3)	———	———	———
Mathematics 520	5 (41.7)	6 (50.0)	1. (8.3)	———	———
* Mathematics 538.1	———	———	———	———	———
Workshop	9 (75.0)	2 (16.7)	1 (8.3)	———	———
Refresher	11	1	———	———	———

* Not taken at time of survey

Table 3

Student Rating of Program and Services

Item	Pre Test 1	2	3	4	5	Post Test 1	2	3	4	5
1. The educational philosophy of this program	83.3	8.3	8.3	0.0	0.0	41.7	50.0	0.0	8.3	0.0
2. My experience (general) at L.I.U.	50.0	33.0	8.3	0.0	8.3	41.7	50.0	8.3	0.0	0.0
3. Counseling	33.0	25.0	41.7	0.0	0.0	16.7	25.0	50.0	8.3	0.0
4. Faculty Teaching Ability	83.3	8,3	0.0	0.0	8.3	58.3	33.3	8.3	0.0	0.0
5. Faculty Attitude	75.0	16.7	0.0	0.0	8.3	75.0	16.7	8.3	0.0	0.0
6. Level of Courses	66.7	33.3	0.0	0.0	0.0	50.0	41.7	8.3	0.0	0.0
7. My Performance	66.7	25.0	0.0	0.0	8.3	58.3	41.7	0.0	0.0	0.0
8. Non-academic Services	16.7	8.3	75.0	0.0	0.0	8.3	41.7	33.3	8.3	8.3
9. Transportation	25.0	33.3	25.0	16.7	0.0	16.7	25.0	25.0	16.7	16.7
10. Parking	8.3	16.7	50.0	16.7	8.3	0.0	0.0	50.0	25.0	25.0
11. Dining	0.0	0.0	83.3	8.3	8.3	0.0	41.7	58.3	0.0	0.0
12. Library	0.0	33.3	58.3	8.3	0.0	8.3	16.7	75.0	0.0	0.0

Ratings 1=very satisfied 2=somewhat satisfied 3=neutral
4=somewhat dissatisfied 5=very dissatisfied

Table 4

t-Tests for Student Ratings of Programs and Services

Item	N	Pre-Test Mean	Post-Test Mean	t-Value	Probability
Educational philosophy of this program	.12	1.42 (1.17)	1.75 (.86)	-.70	N.S.
My experience (general) at L.I.U.	1.12	1.83 (1.19)	1.66 (.65)	.41	N.S.
Counseling	12	2.08 (.90)	2.50 (.91)	-1.1	N.S.
Faculty teaching ability	12	1.42 (1.16)	1.50 (.67)	-.20	N.S.
Faculty attitude	12	1.50 (1.17)	1.33 (.65)	.41	N.S.
Level of Courses	12	1.33 (.50)	1.58 (.67)	-1.15	N.S.
My performance	12	1.58 (.17)	1.42 (.52)	.41	N.S.
Non-academic services	12	2.58 (.80)	2.67 (1.07)	-.23	N.S.
Transportation	12	2.33 (1.07)	2.92 (1.38)	-1.40	N.S.
Parking	12	3.00 (1.04)	3.75 (.86)	-1.91	N.S.
Dining	12	3.25 (.62)	2.58 (.51)	3.55	**
Library		2.75 (.62)	2.67 (.65)	.27	NS.S

**Significiant beyond the .01 level

Table 5

Self Concept of Ability Ratings
N=12
(Percent agreement)

Item	Response	Pre-test	Post test
When I think about studying math I feel:	Very Confident	8.3	41.7
	Somewhat Confident	50.0	41.7
	Somewhat Insecure	41.7	16.7
	Very Insecure	0.0	0.0
When I teach math I feel:	Very Confident	25.0	33.3
	Somewhat Confident	66.7	66.7
	Somewhat Insecure	8.3	0.0
	I never teach this subject	0.0	0.0

Table 6

t-Tests for Studetn Self Concept Items

Item	N	Pre-test Mean (SD)	Post-test Mean (SD)	t-Value	Probability
When I think about studying math I feel	12	2.33 (.65)	1.75 (.75)	2.55	*
When I teach math I feel	12	1.04 (.30)	.49 (.14)	1.30	N.S.

Table 7

Mathematics Content

N = 16

	Pre-test	Post-test
Mean	8.8	23.7
Meadian	8	23.0
Range	4-18	21-27

LONG ISLAND UNIVERSITY

The Hellman Academy for Mathematics and Science Teacher Education Retraining

Inventory Test for Math

Version A

NAME: _____

1. If the reciprocal of $x + 1$ is $x + 1$, then x

   1. is 1 or -1
   2. is 0 or -2
   3. is undefined
   4. has an infinite number of values

2. If $x = 8$, the value of $3x^{-\frac{2}{3}} + 2x^{0}$ is

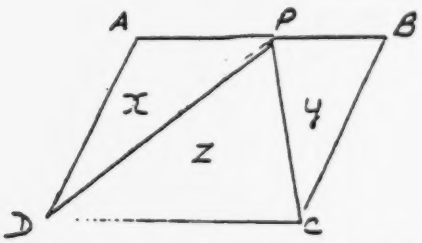
   1. $\frac{11}{4}$
   2. 14
   3. $\frac{7}{4}$
   4. 13

3. If set A has k elements, the total number of subsets of A is

   1. 2^k
   2. 2^{k-1}
   3. $2^k - 1$
   4. $2^k + 1$

4. If an automobile travels 80 miles at the rate of 20 miles per hour and then returns over the same route at the rate of 40 miles per hour, the average speed in miles per hour for the entire trip is

   1. $26\frac{2}{3}$
   2. 30
   3. $33\frac{1}{3}$
   4. 60

5. 

Point P is any point on side AB of parallelogram ABCD. X, Y, and Z are the areas of the triangles formed. The ratio of the sum of the areas of $\triangle X$ and $\triangle Y$ to $\triangle Z$ is

   1. 1:1
   2. 1:2
   3. 2:1
   4. 1:3

NAME: _____

6. One of the roots of $x^3 - x^2 + x + 3 = 0$ is

1. $i\sqrt{2} - 1$
2. $i\sqrt{2} + 1$
3. $2i\sqrt{2} - 1$
4. $i\sqrt{2}$

7. If $a * b$ is defined as $\frac{2a-b}{a+b}$, what is the value of $3 * (3 * 3)$?

1. $-\frac{4}{7}$
2. $\frac{1}{2}$
3. $\frac{11}{7}$
4. 27

8. If the domain of x is all real numbers, which of the following relations is also a function?

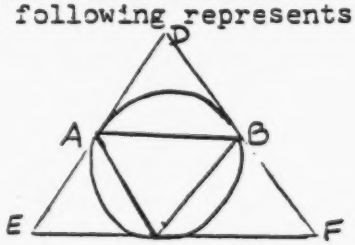
1. $\{(x,y) \mid x=y^2+2\}$
2. $\{(x,y) \mid y=x^2-2\}$
3. $\{(x,y) \mid x^2 = 2-y^2\}$
4. $\{(x,y) \mid y \quad x-2\}$

9. Solve for x: $3-2x \quad 7$

1. $-2 < x < 5$
2. $x > 5$ or $x < -2$
3. $-5 < x < 2$
4. $x > 2$ or $x < -5$

10. In the diagram shown, equilateral triangle ABC is inscribed in the circle and equilateral triangle DEF is circumscribed about the circle. If the difference of the areas of these two equilateral triangles is 24, which of the following represents the area of triangle ABC?

1. 6
2. 8
3. 12
4. 16



11. The graph of the equation $y = 8 \cos 3x$ has a period equal to

1. $\frac{1}{3}\pi$ radians
2. $\frac{2}{3}\pi$ radians
3. 3 radians
4. 3π radians

12. Find $\lim_{x \to 0} \frac{3 \sin x}{x}$

1. 1
2. does not exist
3. 3
4. 0

NAME: _____

13. A sack contains 5 blue marbles and 4 red marbles, identical except for color. Two marbles are removed at random without replacement. The probability that the two match in color is

1. $\frac{4}{7}$ 2. $\frac{5}{9}$

3. $\frac{7}{12}$ 4. $\frac{5}{8}$

14. Given that p is false and q is false. Which of the following is false?

1. $p \rightarrow q$ 2. $p \rightarrow \sim q$

2. $\sim p \rightarrow q$ 4. $\sim p \rightarrow \sim q$

15. If "brother " is a relation, which of the following statements is true?

1. The relation is reflexive, symmetric and transitive.
2. The relation is transitive but not symmetric.
3. The relation is reflexive but not transitive.
4. The relation is not reflexive, not symmetric and not transitive.

16. Set A contains exactly 25 points, no three of which are collinear. The total number of line segments which may be drawn connecting pairs of points in A is

1. 150 2. 300
3. 600 4. 625

17. In $\triangle ABC$, a = 3, b = 4, and $m\angle c = 120$. The length of side c is

1. $\sqrt{13}$ 2. 5
3. $\sqrt{31}$ 4. $\sqrt{37}$

18. If the edge of a cube has unit length, then the length of the diagonal of the cube is

1. $\sqrt{2}$ 2. 2

3. 3 4. $\sqrt{3}$

19. For any real value of x, the maximum value of the function $y = 5x-2x^2$ is

1. $\frac{5}{2}$ 2. $\frac{25}{8}$

3. $\frac{5}{4}$ 4. $\frac{25}{4}$

NAME: _____

20. If $x^3 + y^3 = 3xy$, then $\frac{dy}{dx}$ =

1. $x^2 + y^2$
2. $\frac{x-x^2}{x}$
3. $\frac{y-x^2}{y^2}$
4. $\frac{y-x^2}{y^2-x}$

21. The multiplicative inverse of 1 + 2i in a+bi form is

1. $-\frac{1}{3} + \frac{2}{3}i$
2. $-\frac{1}{5} + \frac{2}{5}i$
3. $\frac{1}{3} - \frac{2}{3}i$
4. $\frac{1}{5} - \frac{2}{5}i$

22. If $\frac{x+y}{x-y} = \frac{2}{3}$, what is the vlaue of $\frac{x}{y}$?

1. 1
2. -1
3. $-\frac{1}{5}$
4. -5

23. An equation of a line perpendicular to the line x-y=3 and passing through the point (2, 3) is

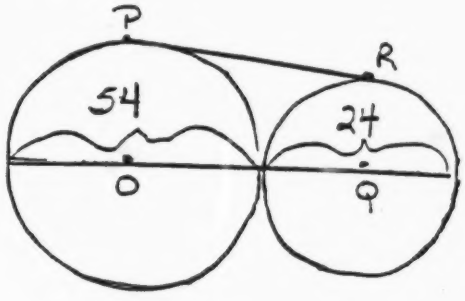
1. 2x - y = 1
2. x + y = 5
3. y - x = 1
4. 3y - 2x = 5

24. The value of m in $\log_8 m - \log_8 4 = \frac{2}{3}$

1. $\frac{1}{2}$
2. 2
3. 16
4. 4

25. Two circles of diameter 24 ft. and 54 ft. are externally tangent. Find the length of one of their common external tangents.

1. 12 ft.
2. 18 ft.
3. 29 ft.
4. 36 ft.



NAME: _____

26. The area bounded by the graph of $f(x) = \frac{1}{x^2}$ ($x > 0$), the x = axis and the lines $x = 2$ and $x = 3$ is

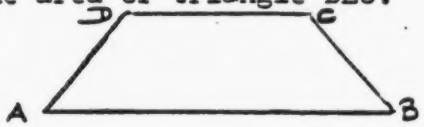
1. $\frac{1}{9}$
2. $\frac{1}{6}$
3. $\frac{1}{4}$
4. $\frac{13}{72}$

27. Two names each associated with a surface that can have only one side, are

1. Euler, Jordan
2. Jordan, Klein
3. Klein, Moebius
4. Moeius, Euler

28. In the accompanying figure, ABCD is an isoscels trapezoid. Bases AB and DC are 30 and 18 respectively, and leg BC=10. $\overline{AD}$ and $\overline{BC}$ are extended to meet at E. Find the area of triangle DEC.

1. 72
2. 80
3. 108
4. 120



29. The graph of $\{(x, y) \mid ax^2 + by^2 = c\}$ Where a, b, and c, are real numbers, CAN NOT be a

1. circle
2. parabola
3. ellipse
4. hyperbola

30. The series represented by $\sum_{K=1}^{n} (2k-1)$ is equal to

1. n^2
2. $(n + 1)^2$
3. $\frac{n(n-1)}{2}$
4. $n(n+1)$

**

APPENDIX III

EVALUATION REPORT

1985-1987

**

EVALUATION REPORT

THE HELLMAN ACADEMY FOR MATHEMATICS AND SCIENCE TEACHER EDUCATION RETRAINING

Supported by

The Fund for the Improvement of Postsecondary Education

1985-87

Dr. Carole Kazlow

March, 1987

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APPENDIXES

I Long Island University Students' Pre Test

II Long Island University Students' Post Test

III Director's Questionnaire

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V Student Dissemination Site Questionnaire

PROGRAM DESCRIPTION

This is the third and final year of a three-year grant designed to retrain experienced teachers in the disciplines of mathematics and physics. The model, developed at Long Island University over a period of many years, represents an innovation in teacher training. The primary objective of the model is to train teachers from other disciplines and/or grade levels as secondary school teachers of mathematics and science.

As stated in the original proposal, the plan was to disseminate the model to two Regional Sites and then to two National Sites, to be selected from Universities located in Federal Regions V-X. The characteristics that distinguish this model from a more traditional teacher training program are that the curriculum, a graduate program, assumes little or no prior knowledge of mathematics and/or physics and proceeds to cover, in mathematics, for example, elementary algebra, geometry, trigonometry, differential and integral calculus, a course whose topics include number theory, logic, probability, projective geometry and topology. The design of the calculus sequence is intuitive and stresses applications. A similar modualar approach applies to the physics model.

The structure, or delivery system, of this intensive program is to present the courses in a sequential manner to the students who go together as cohorts from course to course

EVALUATION DESIGN AND OBJECTIVES

The major focus of this year's evaluation is to determine the extent to which the program has been disseminated. Thus, the evaluation is primarily formative in nature as it describes the implementation process at each site. In addition, some summative data is provided. During the second year of the grant (1984-85) the model was successfully adopte. (see 1984-85 evaluation report) by the University of Kentucky, the University of Miami, Beaver College and a suburban school district in Great Neck, New York, as well as continuing at the original Long Island University Site.

During 1985-86 several sites continued their implementations, i.e. Beaver College, University of Miami and Long Island University. In addition, six new sites adopted the model: Arizona State University, University of Northern Colorado, Portland Public Schools, Texas Woman's University, Trenton State College, and Western Oregon State University. As in past years, the local site directors were in constant communication with the Project Director. The Project Director visited each site. At these times she observed classes, spoke with students and faculty and had meetings with local project directors, university or college administrators. Local project directors were encouraged to

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* Self supporting

** Supported in part by funds from New Jersey Department of Higher Education.

call the director at Long Island University when they had problems or wanted to discuss the progress of the program at their sites. Local project directors were required to provide progress reports of their activities. In this way the Long Island University project director was kept up to date with regard to on-site activities and monitored the financial aspect of the program. The Long Island University project director also met with local site directors several times over the course of the year when attending regional and national conferences.

DATA COLLECTION

Data for the evaluation was gathered from a variety of sources. The Project Director was interviewed several times over the course of the year. In addition, local site directors were interviewed.

Several paper and pencil instruments were designed. All local directors received a package of questionnaires and were instructed to complete the director's questionnaire and to administer the survey instrument to the students in their program. Local directors were also asked to give a specially developed faculty questionnaire to faculty teaching in the program. Faculty were asked to send the questionnaire directly to the project evaluator in order to preserve confidentiality. The Long Island University group completed two instruments: one at the beginning of the academic year and one at the end. Only one director, from Arizona

State, failed to return the evaluation materials as requested.

The following sections of this report summarize the results of this data collection effort. First the evaluation of directors, faculty and students are reviewed. Then a site by site review is presented.

RESULTS

Director's Evaluation of Program

In order to evaluate the program, local directors were asked to evaluate several aspects of the program. Table I presents the director's assessment of the reasons for attending. The most significant reasons for leaving had to do with the academic aspects of the program. Directors felt that for some students the time demands proved to be excessive, the pace was too fast and the work too difficult.

When directors were asked to rate various aspects of the program at their sites (Table 2) they were generally satisfied with most aspects of the program. All directors reported being "very satisfied" with the teaching faculty. Local directors were satisfied with the services provided by the Long Island University director and with services provided locally. Directors were also asked to evaluate variables which, if problematic, would explain failure to implement. The major problem areas were financial, student recruitment and student retention.

An assessment of a program such as this one, where model dissemination is the objective, must examine the degree to which plans have been made to institutionalize or incorporate the program into the sturcture of the local organization. To address this question, directors were asked to evaluate services they felt were needed to continue the program. Financial assistance was perceived as being "very important" for continuance.

Finally, the directors were asked if they had made plans to continue next year. (Table 5) Six of the seven said "Yes." The seventh, Miami University, is a unique case in that the Dade County Public School system is offering their own, tuition-free, retraining program which in addition to not costing the students anything is far less rigorous in nature, and for which students are paid to attend.

The fact that the program is being institutionalized in the majority of sites speaks to the success of the program. It especially addresses the issue of adaptability. The model (innovation) has been adopted, implemented and is now being incorporated in a very varied group of colleges, universities and public school districts throughout the country.

Faculty Evaluation of Program

Ten faculty members from six sites (Trenton, Portland, T.W.U., Miami, Oregon, Beaver) completed the Faculty Site Evaluation Form (See Appendix 4). Six of the ten hold the doctorate in mathematics and the remaining four have master's degrees in mathematics. All majored in mathematics.

Five of the faculty are full-time members of mathematics departments. Four are adjuncts in the mathematics department and one is an adjunct in the Education Department.

The faculty were presented with a series of questions designed to assess the degree to which the model has been implemented at the various sites and to give the faculty the opportunity to rate the students in the program as well as the local site directors. In addition, faculty were asked to respond to several open-ended items. When asked to what extent the course or courses they taught had been modified from what they were initially presented with, six of the ten respondents checked "not at all" and four only "somewhat." There appeared not to be a need for major course revision at any of the sites. Faculty were asked to think back to the way the program was initially described and to give their opinion as to whether or not this initial description accurately reflects the program. The respondents were unanimous in their affirmation of the fit between description and that which is being implemented. This speaks to the clarity of the innovation and demonstrates that the L.I.U. Project Diretor clearly explained the model to each site director, who in turn was able to communicate effectively with project faculty at the sites. Without clarity, implementation is unlikely. Therefore, this key aspect of the L.I.U. Project Director's role in the dissemination effort can be viewed positively.

Faculty rated their students and their local project directors. For the most part faculty ratings of student

motivation, attendance and attitude toward the professor was outstanding. The majority gave an "A" rating to these components of the student role. Performance in class and on exams were primarily in the "B" category. The only area to receive "C" ratings was the area of mathematical background and this, of course, reflects the known limited background of the students.

Using the same rating scale (A to F) faculty were asked to evaluate the abilities and activities of the local project director. The model response across categories was "A." There were no ratings below "B." This faculty group has a very favorable and positive attitude toward the ability of the director at their site. Moreover, their ratings signify that the directors played their roles adequately. This too, was an important factor in explaining the successful implementation of the model at the various sites. Earlier, clarity of the innovation was alluded to. Apparently the local directors' accessibility to faculty and students, their supportiveness and knowledge were important aids in the implementation process. The L.I.U. Project Director should be cited for her astute selection of sites and local directors. This is another key to successful adoption of innovations.

Students' Evaluation of Program

Questionnaires (see Appendix 5) were distributed and collected from 72 students in five sites (Trenton, Colorado, Portland, T.W.U., Beaver) in addition to a separate

questionnaire (see Appendices 1 and 2) administered to students at L.I.U. Of the seventy-two student respondents, 26 were male and 46 were female. They ranged in age from 24 to 51 with a mean age of 36.8 years. Their undergraduate educational background revealed a great degree of variation. The greatest number of students (19) majored in elementary education followed by biology (13). The remaining students majored in history (6), English (5), mathematics (3), and one or two in each of the following areas: chemistry, physics, speech, art, philosophy, special education, industrial arts, architecture, economics, business, geography, psychology, music, and political science. Almost 40% of the students in the sample already had a master's degree. When asked to rate the quality of their undergraduate work, 65.7% said they were "above average." Not one student checked "below average" on this anonymous and confidential questionnaire. 88.8% of the students are currently teaching. This group of students' number of years teaching experience ranges from one to twenty-four years. Most of those who are currently teaching have been in their fields for a relatively long time. Their average years of service in their current position was 7.07 years. The level of teaching for those currently employed in the profession also varied. Forty-two percent were teaching at the senior high school level, 5.2% at middle school, 35% in junior high school, and 17.4% at the elementary level. Most of the FIPSE population in this sample were teaching at the secondary level. Of the secondary teachers, 74.5% were

already teaching mathematics or science.

A series of items were included to determine students reasons for attending this special program. The students in this sample were drawn to the program not only by desire to teach a particular subject, but by the time period necessary to complete the retraining, the desire to obtain certification and the affordable tuition. Only 20.8% of the students surveyed said they would be going to graduate school if not for this special program. Fifty-six point nine percent said they would not be attending and 22.2% did not know. Students' response to this item demonstrates that the appropriate target group was reached.

A final question in this section of the questionnaire asked the students to think back to how the program was initially described to them. They were then asked how accurately the program reflected that initial description. The answers to this question, if affirmative, demonstrates that the program, as described in the recruitment phase has been implemented. 85.2% of the students said "yes."

The students in this phase of the program were generally confident with respect to their perception of their own ability to study mathematics (physics) at a university as well as fairly confident of their ability to teach the subject (see Table 7-8). The last of the series of close-ended items asked students to evaluate various aspects of the program as they had experienced them at their college or university. These items revealed an overall high level of satisfaction with the program, the philosohpy behind it,

experiences at the local sites, the teaching ability of the faculty and, foremost, the attitude of the faculty. Although the program was viewed as being challenging and difficult, 90% of the students were satisfied with their own performance. Very few items elicited dissatisfaction. Indeed, the only item to elicit greater than 10% dissatisfaction was the rating of the text books assigned.

To summarize, this aspect of the evaluation reveals a group of students, (the majority of whom were female), with a wide variety of academic backgrounds but who rated themselves as average or above average undergraduate students. The students started out being confident with regard to their ability to study and teach mathematics or physics. They were attracted to the program for a multiplicity of reasons. However, the time-frame was particularly appealing to this group of experienced teachers from other disciplines. Had it not been for this non-traditional program and the opportunity it offered, most of these students would not have enrolled in a traditional program and there would be that many fewer new teachers in these areas.

PROGRAM DESCRIPTIONS

University of Miami

The School of Education and Allied Professions at the University of Miami together with the Mathematics Department has been implementing the Long Island University model for

teacher retraining. The purpose of the program is to provide teachers with the necessary coursework to prepare them for certification in secondary school mathematics.

Most students work in the Dade County Public School District, the fourth largest in the nation according to the local director, Dr. Gilbert Cuevas, Professor of Mathematics and Computer Education and a member of the Department of Educational and Psychological Studies in the School of Education. Twenty individuals, 15 male and five female applied to the program. All were accepted, but only eight began and completed the program. He explains this relatively high attrition rate as a consequence of the competition from a similar state funded teacher retraining program offered at no cost to teachers by Dade County Public Schools. The major implementation problems at this site reflected this. They were financial, student recruitment and student retention. For these reasons the program is not currently being offered. In addition to free tuition, teachers are paid their hourly rates for attending the courses by Dade County. A most positive effect was the cooperation that developed - never before there - between the School of Education and Department of Mathematics.

Arizona State University

Arizona State University is part of a three-university system governed by the Arizona Board of Regents. The Project Director at this site is Dr. Lehi T. Smith, Professor of Mathematics. This department has a long history of close

cooperation with the College of Education in the preparation of teachers of mathematics.

Thirty-four students started the program. Dr. Smith has been very satisfied with the model. He said, "I am continually receiving calls from teachers who have heard about the program and are wondering how they can get in line to be considered as participants in the next group". Many lectures have been taped for presentation to Native American Indians. Students in the program are equally happy with the opportunity they have been offered. One said, "This is the only program like this anywhere. I have been waiting for it." Another said, "This graduate credit was essential." (Report Attached)

Beaver College

THA-MASTER began at Beaver College in the spring semester of 1985. There were 21 applicants: 17 female and 4 male. Of the 21, 18 were accepted, 14 female and 4 male. All 18 started the program. Of the eighteen, 11 females and 2 males, or 72% completed. When asked to explain the attrition, the director of the program felt it was related to the pace of the classes, the time demands and the difficulty of the work.

The director was satisfied with all aspects of the program and said that his major reason for adopting the model is that it was very well designed. The problems he reported, though minor, were related to difficulty with non-project

faculty, student recruitment and student retention. Part of the problems had to do with timing. He said they did not have sufficient time to plan and advertise the program. Dr. Polis, the local site director, used the program as a model and applied for and was awarded a series of grants totaling $235,500 by the Pennsylvania Department of Education under Title II EESA. They will use this money to continue the program next year and to apply the model to the retraining of teachers from other disciplines into chemistry and physical science. Seventy-five teachers have been selected to participate.

University of Northern Colorado

The University of Northern Colorado (UNC) has been designated by the Colorado Commission on Higher Education as the premier teacher education institution in Colorado. The program at UNC differs from that at the other sites in that the retraining emphasis is physics. The program was initiated midsummer 1985 and was offered by the Physics Department. Dr. Paul A. Lightsey, Chairperson, Department of Physics is the local Project Director. A total of 56 individuals, 32 males and 24 females applied to the program. 31 were accepted (18 male, 13 female). Of the 31, 28 actually started taking courses and 21 completed the program (15 male, 6 female). The three categories which were checked by the director to explain attrition had to do with the difficulty of the work, the pace of the classes and the time demands. The director was satisfied with all aspects of the

program. He was especially satisfied with the quality of the students and the faculty. The problems reported, again "minor", had to do with financial resources and the availability of materials. Financial resources to reach a rural population is a major obstacle to the dissemination of the program in rural areas. An adjustment the director would like to make in the future would be to extend the coursework over two years with more intensity in the summer and less during the academic year. Another desirable change for the site, suggested by this director, would be to implement an intensive on campus summer program with telecommunication links to rural sites for the academic year portion.

The director has definite plans for continuing the program next year. He also feels the model could be extended into Chemistry and perhaps Earth Science and Biology. THA-MASTER courses will be used as part of an interdisciplinary master's degree program.

Portland Public Schools

The Portland Public school site of the THA-MASTER is the only dissemination site this year located in a public school system rather than at a college or university. The faculty, both of whom teach part-time at local universities, are full-time high school mathematics instructors in the Portland Public Schools. This peer teaching relationship has proven to be one of the outstandingly beneficial aspects of the Portland program.

THA-MASTER was adopted as a consequence of the search

by the then Superintendent of Schools, Dr. Peter R. Greer, for a program which they could use to retrain current staff to meet the critical shortage of mathematics teachers. Dr. Greer appointed his assistant, Reginald MacDonald, to head this effort. Mr. MacDonald is the Project Director. The program was initiated in August 1985. It was designed to be a two-year program. The school system is paying for the teachers' tuition. Initially, 11 students (5 male, 6 female) applied. All were accepted and started the program. Nine students, 4 male, 5 female, are still in the program. The reason given by the director for attrition was "the time demands of the program were excessive". The director was very satisfied with all aspects of the program. The only implementations problems cited (minor) had to do with financial resources, difficulty with project faculty, student recruitment and retention. No changes were made in the original design. The Long Island University program was followed exactly.

The Portland School District has already made plans to continue and to institutionalize the program. A budget has been approved and courses have been scheduled.

Texas Woman's University

The program was initiated at this site during the second session of 1985. The Project Director is Dr. Rose Marie Smith, Professor of Mathematics and Chairperson of Mathematics. From the very beginning, she felt the program had great appeal.

Thirty students, 23 female and 7 male applied. Twenty, 5 male and 15 female, were accepted. Fifteen started taking courses and 14, 12 male, 2 female, completed the sequence. Dr. Smith said that the most significant reasons for leaving had to do with the difficulty of the work and the fast pace of the classes. She was very satisfied with the services provided by L.I.U. and her own university as well as with the teaching faculty and somewhat satisfied with all other aspects of the program. She said, "The THA-MASTER program is very supportive of the activities already being pursued by our faculty, department and university. This was my impression when I made my initial request to be included in the program. This continues to be my impression." She also cited as important the way in which the model responds to the need for mathematics teachers. Dr. Smith found the opportunity to work closely with professionals from other areas of the country to be stimulating.

The major problem areas, as far as implementation is concerned, had to do with financial resources, student recruitment and retention. She found that many students need a slower pace to be successful in mathematics. The modification made at this site was to offer two courses, college algebra and college trigonometry, before introducing the calculus sequence. This qualifies the student for secondary certification in mathematics in the State of Texas.

Dr. Smith has made plans to continue the program next year. She would like to see the model extended to address

the need for training elementary teachers in mathematics, training special education teachers and bilingual teachers. (Report attached)

Trenton State College

The program at Trenton State College is housed in the Department of Mathematics and Computer Science. Dr. Michael A. Iannone, Chairman, Mathematics and Computer Science Department, is the local project director. Among the highlights of the program at Trenton are that it is tuition-free. All courses, except for summer, meet twice a week, four hours per session for an eight week period. 24 credits in mathematics are offered. At the end of the program, assuming the student passes the NTE, they will qualify for State Certification. To enable the student to obtain certification, 2 courses were added. The program attracted 93 applicants. 34 were accepted and twenty-five completed the program. Among the explanations offered for attrition, the most significant was the excessive time demands of the program. Next most important was the difficulty of the work and the fast pace of the classes. The director was very satisfied with the quality of the students and faculty and the structure of the program. He was also satisfied with the content of the courses, the Long Island University services, and the services of his college. The only area that he was somewhat dissatisfied with was the recommended textbooks. What attracted him to the program was that it seemed to offer a vehicle to reach his objectives through a tested program.

"We were able to follow a model which certainly gave us direction in getting involved in the business of retraining," said the director.

When asked to indicate implementation obstacles at his site, the areas cited were financial resources, availability of materials, and student retention. Other than adding courses to assure statewide certification criteria would be met, no major changes were made.

Plans have been made and funding obtained to continue the program. (Report attached)

Western Oregon State College

The Mathematics Department of Western Oregon State College has joined the network of THA-MASTER in order to train skilled and experienced teachers who are already certified in other disciplines.

Oregon's Teacher Standards and Practices Commission for Certification requires "competencies" in geometry, algebra and calculus plus two methods courses in mathematics. Most of the people who are interested in the program have as their number one objective certification in mathematics as soon as possible. Scheduling that provides survey and refresher courses alleviates the problems that entering teachers may have who have been away from mathematics for a long time.

Many of the participants live in rural school districts far from colleges and are not able to take the calculus sequence in the usual manner during the school year. The

opportunity to meet this requirement by using video-taped presentations and having regional problem-solving sessions is a unique element of Western's program. This was made possible through the FIPSE component of the Hellman Academy. By means of the instant replay system, key lessons are videotaped and the syllabi, which include weekly assignments, are provided. Regional centers are established where local participants meet weekly for problem-solving sessions.

Twenty-three graduate credits in the THA-MASTER program plus six credit hours meeting state certification requirements lead to mathematics certification. There is an opportunity to utilize the coursework in a Master of Science program and expand the students' understanding of the full character of mathematics and its role in society. This site is unique in that its students are from rural areas and the problems with getting the courses to students in far flung areas are different than in urban settings. Much of the work was done with video tapes, especially the calculus.

Thirty-three students, (16 male 17female) started the program. Only 8, 4 male and 4 female, completed. The director felt the most significant explanation for the high attrition rate is that the students were not prepared to make a continuing commitment. The next most important reasons cited were the difficulty of the work, the fast pace of the classes and the excessive time demands. He also felt that the participants major motivation is to obtain mathematics certification in Oregon. This requires certain specific course work. The director feels that some of the students

elected to take only the part of the sequence needed. Finally, the distance necessary to travel affected some.

The director was very satisfied with the faculty teaching the courses, the course content and the services provided by L.I.U., and somewhat satisfied with all other areas of the program. The major obstacles of implementation cited were the availability of teaching materials and student retention. The adaptations made include the use of the videotaped calculus program and some minor revisions of course content to meet Oregon certification requirements. The director would like to obtain financial support to expand the video portion of the program to include classes other than calculus. Steps have been taken to continue the program next year. (Report attached)

Long Island University

THA-MASTER, the model, was developed with funds from the National Science Foundation from 1977-1981. It has been supported by a grant from the Fund for the Improvement of Postsecondary Education (FIPSE) for the last three years (1983-1986). The major objective of this grant was to test the efficacy of the model's adaptability by disseminating it to other sites throughout the United Stated in order, ultimately, to produce qualified teachers in specific areas of need, i.e. mathematics and physics. In addition to the dissemination results discussed, there was a mathematics retraining program at L.I.U. during the 1985-86 academic

year. Twenty-five students started the program and eighteen completed. A questionnaire was administered to the twenty-five students. Analyses of the responses to this survey instrument revealed a predominantly female (70%) population with a mean age of 37.4 years. The students had a wide variety of academic backgrounds. Of the 25, seven had majored in elementary education, 5 in history, 3 in biology, and one or two in psychology, economics, business, art and physical education. 39.1% of the students already completed a master's program. When asked to describe the quality of their undergraduate work, 37.5% rated themselves "above average". This was an experienced group of teachers with an average of 6.3 years of service, ranging from 1 to 18 years. All the students at the L.I.U. site were teaching during the grant period. 43.4% at the high school level, 47.8% at the junior high school level and 8% at the elementary level. The subject most frequently taught by the secondary teachers in the sample (N=13) was mathematics. When asked if they are certified in the subject they currently teach, 83% answered "no".

The characteristics of this group demonstrate the need for the program. A large number of teachers are teaching mathematics, and other subjects as well, without being formally prepared to do so.

Table 2 reviews the student's reasons for applying to this program. The reason selected most frequently was to obtain state certification, followed by the appeal of the

short time frame.

When asked if they would be attending graduate school for training in mathematics were it not for this special program 32% said yes, while 68% said "no" or they did not know. Again, as in the dissemination sites, the program filled a need that the traditional master's in mathematics was not addressing.

The students (87.5%) felt that the program had been accurately described to them initially. Those who believed there was a discrepancy between what they expected and what they experienced, pointed to their lack of preparedness for the rapid pacing of the courses. This sample of students was fairly confident with respect to their ability to study and teach mathematics (Table 10). Very few students expressed feelings of insecurity.

For the final series of items, L.I.U. students were asked to react to various aspects of the program on a scale which ranged from very satisfied to very dissatisfied. On the whole students were satisfied with the program. The areas of greatest dissatisfaction were with textbooks (32%) and their own performance in the program (40%).

Students were asked to grade each of the courses they completed on a scale of A to F. A was the modular response for all courses. There were very few C,D, or F ratings.

Most of the L.I.U. students had not yet taken the New York City license examination for teaching mathematics by June 1986. Only 3 reported taking the senior high school exam. Two of the three passed. When asked if they felt the

program had prepared them to take the New York City Examination, 70% said "Yes".

By the end of the project year 68% of the L.I.U. students were teaching mathematics and expected to be teaching mathematics during the next year. Only 15% did not plan to be teaching mathematics next year.[1]

SUMMARY AND CONCLUSIONS

The objectives of the program for the third year, as specified in the proposal, were accomplished and in some instances exceeded. The dissemination effort has been particularly successful. Most of the pilot sites are supported by FIPSE monies. Several sites have succeded in attracting financing through grants. Local project directors were unanimous in their support for the project generally and the specific, personal quality of the assistance received from the L.I.U. Project Director. Local project directors are working together to institutionalize the network which has developed as a consequence of participating in the program. All sites are "graduating" a group of students,

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[1] Actions taken by the Division of Education made it virtually impossible for students to use THA-MASTER courses toward a master's degree, a distinct departure from past practices. Therefore, for the first time in almost a decade, few students have gone on to a master's degree at L.I.U.

most of whom will be fully certified to teach in their states. All together more than two hundred students were fully trained over the course of this grant. This program can be used as a model retraining program with proven adaptability. It can be extended to many other areas. Dr. Madeleine Long is to be commended for the leadership she has offered to her colleagues throughout the country.

TABLE 1

Directors Evaluation of Program
(N=7)

Reasons for Leaving

	Very Significant	Somewhat Significant	Not Significant	Don't Know
Work too difficult	1	4	1	
Pace too fast	1	4	1	
Time demands excessive	2	4	1	
Student did not understand what was involved			5	1
Student not prepared to make a commitment	1	1	2	2

TABLE 2

Director's Rating of Program Components

(N=7)

	Very Satisfied	Somewhat Satisfied	Somewhat Dissatisfied	Very Dissatisfied
Quality of Students	4	3		
Teaching Faculty	7			
Course Content	4	3		
Recommended Texts	2	4	1	
Structure of Program	2	5		
Services Provided by L.I.U.	4	3		
Services Provided by Local College of University	3	4		

TABLE 3

Director's Evaluation of Implementation Problems

(N=7)

Problem	Major	Minor	Not a Problem
Financial Resources	2	5	
Availability of Materials	2	2	3
Difficulty with project Faculty		1	6
Difficulty with non-project Faculty		1	6
Local Administrative Support		2	5
Student Recruitment	2	3	2
Students Retention	3	3	1

TABLE 4

Director's Evaluation of Services Needed for Continuing Efforts

	Very Important	Somewhat Important	No Important
Entire Long Island University Package	1	5	1
Technical Assistance		4	3
Financial Assistance	6	1	

TABLE 5

Director's Plans to Institutionalize

Yes	6
No	1

TABLE 6

Students' Reasons for Applying*

(N=72)

Reason	Number Responding
Short time period	41
Always wanted to teach mathematics (Physics)	39
To obtain State Certification	36
Tuition is affordable	24
To help get a job in a secondary school	23
To help me get a job	21
I needed a change	20
Interest in subject	9

* Students were instructed to check as many reasons as apply. Therefore, totals will vary.

TABLE 7

Perceived Self Concept of Ability to Study and Teach Mathematics
(Percentage)

Item	Response			
	Very Confident	Somewhat Confident	Somewhat Insecure	Very Insecure
Initially, when I thought about studying mathematics (physics) at a university, I felt:	20.8	59.3	15.2	5.5

Item	Response Category				
	Very Confident	Somewhat Confident	Somewhat Insecure	Very Insecure	I never taught this subject
When I taught mathematics (physics) before I started this program, I felt:	18.6	34.2	7	1	38.6

TABLE 8

Student's Ratings* of Program

(N=72)

Item	Categories** 1	2	3	4	5
Education Philosophy of the program	58.3	16.6	16.6	5.5	2.7
My Experiences at this University	52.7	26.3	13.8	5.5	0
Academic Counseling	37.5	22.2	29.1	6.9	4.1
Teaching ability of Faculty	59.7	27.7	8.3	5.5	0
Attitude of Faculty	71.4	24.3	4.0	0.0	0.0
Level of Courses	54.4	30.0	11.4	4.2	0.0
Text books	34.2	34.0	14.0	12.8	0.0
My performance	54.2	35.7	5.7	4.4	0.0
The Performance of my peers	45.9	27.1	22.8	4.2	0.0

* All ratings are in percentage

** 1 = Very Satisfied

2 = Somewhat Satisfied

3 = Neutral

4 = Somewhat dissatisfied

5 = Very dissatisfied

TABLE 9

L.I.U. Students' Reasons for Applying*

(N=25)

Statement	Number
To obtain State Certification	18
The opportunity to complete a retraining program in a relatively short time appeals to me	13
I always wanted to teach mathematics	12
I needed a change	8
The tuition is affordable	7
To help me get a job in a secondary school	4
To help me get a job	4

* Totals do not add up to 25 as students were instructed to check as many as apply.

TABLE 10

Initial Self Concept of Ability to Study and Teach Mathematics of L.I.U. Students
(N=25)

Item	Response (in percentage)			
	Very Confident	Somewhat Confident	Somewhat Insecure	Very Insecure
Initially When I thought about studying mathematics at a university, I felt:	32.0	52.0	16.0	0.0
When I taught mathematics before I started this program, I felt:	18.0	68.0	14.0	0.0

TABLE 11

Long Island University Students Early Evaluation of Program
(N=25)*

Item	Responses in Percentage				
	1	2	3	4	5
The educational philosophy of the program	45.8	16.6	37.5	0.0	0.0
My experiences (general) at this university	32.0	36.0	24.0	4.0	4.0
The academic counseling which is available	24.0	40.0	32.0	4.0	0.0
The teaching ability of the faculty	52.0	28.0	0.0	16.0	4.0
The attitude of the faculty	60.0	16.0	8.0	12.0	4.0
The level of the courses	40.0	32.0	12.0	12.0	4.0
The textbook assigned	24.0	36.0	8.0	28.0	4.0
My performance in the program	20.0	32.0	8.0	40.0	0.0
The performance of my peers	12.0	32.0	48.0	4.0	4.0

*Responses are reported in percentages:

1 = Very Satisfied
2 = Somewhat Satisfied
3 = Neutral
4 = Somewhat dissatisfied
5 = Very dissatisfied

TABLE 12

Post Self Concept of Ability of L.I.U. Students to Study and Teach Mathematics

(N=18)

Item	Responses			
	Very Confident	Somewhat Confident	Somewhat Insecure	Very Insecure
After my experiences this year, when I think about studying mathematics at a university, I felt:	33.0	5.0	17.0	0.0
When I teach mathematics, I felt:	43.7	50.0	6.2	0.0

**

APPENDIX IV

DISSEMINATION CONFERENCE

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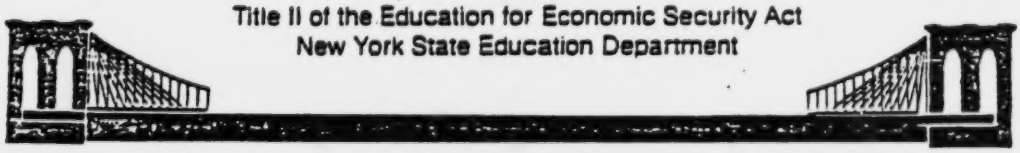
CONFERENCE PROCEEDINGS

The Hellman Academy
for
Mathematics and Science
Teacher Education Retraining
THA-MASTER

Developed with Support from
The Fund for the Improvement of
Post Secondary Education
(FIPSE)
and
Title II of the Education for Economic Security Act
New York State Education Department



FOUNDING SITE

Long Island University
Brooklyn Campus
Brooklyn, New York 11201

THA-MASTER DISSEMINATION SITES

Arizona State University
Tempe, Arizona

Beaver College
Glenside, Pennsylvania

The University of Miami
Miami, Florida

The University of Northern Colorado
Greeley Colorado

Portland Public Schools
Portland, Maine

Texas Woman's University
Denton, Texas

Trenton State College
Trenton, New Jersey

Western Oregon State College
Monmouth, Oregon

CONFERENCE PROCEEDINGS

*****

THE FIRST ANNUAL CONFERENCE OF
THE MASTER NETWORK

The Hellman Academy for Mathematics and
Science Teacher Education Retraining

December 3-6, 1986

SPONSOR: Long Island University, Brooklyn, N.Y.

HOST: InterAmerican University of Puerto Rico

SUPPORTED BY: The Fund for the Improvement of Postsecondary Education, United States Department of Education.

REGENCY HOTEL

SAN JUAN, PUERTO RICO

*****

THA-MASTER DISSEMINATION CONFERENCE

San Juan, Puerto Rico

PROGRAM

December 3, 1986

6:00 p.m.	- Reception
Session I	
7:30 p.m.	- Welcome Remarks - Ramon Cruz, Ph.D., President Inter American University
	Keynote Address - H.O. Pollak, Ph.D.
	MATHEMATICS TEACHING: THE FORCES FOR CHANGE

December 4, 1986

Session II	
8:30 a.m. - 10:30 a.m.	- Site Directors and Representatives
	MODIFICATIONS, DEVELOPMENTS AND FUTURE PLANS FOR THA-MASTER
10:30 a.m.	- Coffee break
Session III	
10:45 a.m. - 12:15 p.m.	- STATE AND FEDERAL PERSPECTIVES AND REACTIONS
	Fred Paul Martin Friedman Luis Martinez Manuel Garcia Morin
12:30 p.m. - 1:45 p.m.	- Lunch
Session IV	
2:00 p.m. - 3:45 p.m.	- THA-MASTER Student Perspectives
	- HAS THA-MASTER WORKED?

Edward Grant, Long Island University
Terry Sime, Western Oregon State College
Lynetta Cole, Texas Woman's University
JoAnn Schuck, Trenton State College
Maureen Guim, Beaver College

Session V

4:00 p.m. - 4:30 p.m. - Site Directors Business Meeting

December 5, 1986

Session VI

8:30 a.m. - 11:45 a.m. - Site Directors Paper Presentations

1. A. Richard Polis
   RETRAINING: THE TIP OF THE ICEBERG
2. Dorothy Kelleher
   RETRAINING TEACHERS THROUGH PEEER TRAINING
3. Gilbert A. Cuevas
   STRATEGIES FOR UNIVERSITY AND SCHOOL SYSTEM COLLABORATION
4. Michael A. Iannone
   RETRAINING TEACHERS IN MATHEMATICS: STANDARDS AND EVALUATIONS
5. Robert Main
   PRESENTATION OF CALCULUS TO RURAL AREAS THROUGH THE USE OF VIDEO TAPES

10:00 a.m. - 10:15 a.m. - Coffee Break

6. Madeleine J. Long, Sheldon Pasner
   PROGRAMATIC ASPECTS OF TEA-MASTER AT LONG ISLAND UNIVERSITY 1972-1986
7. Rose Marie Smith
   WOMEN IN MATHEMATICS: SUCCESS IN RETRAINING
8. Paul Lightsev
   A STRATEGY FOR RETRAINING TEACHERS FOR PHYSICAL SCIENCE
9. Walter Glickman
   RETRAINING EINSTEINS

12:00 p.m. - 1:00 p.m. - Lunch

Session VII

1:15 p.m. - Madeleine J. Long
THA-MASTER: AN OVERVIEW

1:45 p.m. - 4:15 p.m. - FORUM: TEACHING MATHEMATICS AND SCIENCE IN PUERTO RICO

Panelists

Lucy Gaspar

Manuel Gomez

Julio Lopez

Edna Mendez de Ortiz

William Stephens

Moderator

Dr. Manuel García Morin

5:30 p.m. - Reception

The "Japanese House"
Inter American University
Metropolitan Campus

December 6, 1986

Session VIII

9:00 a.m. - 12:00 p.m. - Continuation of THA-MASTER Network and wind up of NSF and FIPSE Projects

CONFERENCE STAFF

Dr. Madeleine J. Long
Conference Director
Director, Institute for the Advancement of Mathematics and Science
Long Island University

Dr. Manuel Garcia Morin
Conference Coordinator
Special Assistant to the President
Inter American University

Dr. Luis A. Martinez-Perez
Conference Coordinator
Chairman, Curriculum and Instruction
Florida International University

CONFERENCE PARTICIPANTS

Ms. Lynetta Cole	- THA-MASTER Graduate, Texas Woman's University
Dr. Ramon Cruz	- President, Inter American University
Mr. Gilbert A. Cuevas	- Professor of Education and Mathematics - School of Education and Allied Health Sciences, University of Miami
Dr. Martin Friedman	- Director of Teacher Education, New Jersey Department of Higher Education
Ms. Lucy Gaspar	- Professor of Education University of Puerto Rico
Dr. Walter Glickman	- Professor of Physics Long Island University, Brooklyn Campus
Dr. Manuel Gomez	- Professor of Physics University of Puerto Rico
Mr. Edward Grant	- THA-MASTER Graduate, Long Island University
Ms. Maureen Guim	- THA-MASTER Graduate, Beaver College
Dr. Michael Iannone	- Chairman, Department of Mathematics, Trenton State College
Ms. Dorothy Kelleher	- Mathematics Teacher, Portland Maine School Systems
Dr. Paul Lightsey	- Chairman of Physics Department, University of Northern Colorado
Dr. Julius Lopez	- Science Program Director Department of Education, Central Office Puerto Rico

Dr. Robert Main	- Professor of Mathematics Western Oregon State College
Dr. Robert Moore	- Associate Dean, School of Education and the Allied Health Science - University of Miami
Dr. Andrew Nickolakis	- Chairman of Mathematics Department Long Island University, Brooklyn Campus
Dr. Edna Mendez de Ortiz	- Director of the Department of Science - University of Sacred Heart
Dr. Sheldon E. Pasner	- Teacher of Mathematics and Computer Science, Brooklyn Technical High School
Dr. Fred Paul, Chief	- Director, Bureau of Mathematics Education New York State Education Department
Dr. A. Richard Polis	- Dean of Graduate Studies, Beaver College
Dr. H.O. Pollak	- Retired, Assistant Vice President Mathematical Communications and Computer Science Research Laboratory, Bell Communication Research
Ms. JoAnn Schultz	- THA-MASTER Graduate, Trenton State College
Ms. Terry Sime	- THA-MASTER Graduate, Western Oregon University
Dr. Rose M. Smith	- Chairman of the Mathematics, Physics, and Computer Department, Texas Woman's University
Dr. William Stephens	- Dean of Science and Technology Inter American University
Dr. David Williams	- Mathematics Educator, Philadelphia School System

THE TIP OF THE ICEBERG

BY

A. RICHARD POLIS

DEAN OF GRADUATE STUDIES

BEAVER COLLEGE, GLENSIDE, PA

We are reminded on a daily basis that we face a crisis in education. I am not sure that all of the national reports about schools and schooling which have been written over the past few years are clear reflections of reality. Yet they do suggest that we need to get our house in order. Certainly the reports of falling test scores are not the only measure of the quality of education available in this country. Since we strive to educate all children, the drop in SAT scores, for example, needs to be interpreted in light of the large numbers of students who now choose to enter college. The community college movement in the 1960's may offer an explanation of this phenomenon.

I believe that the brightest and most talented middle class children are getting a better education today than they did 20 years ago. However, the problem we face may be one of educating children who are much different than the ones we taught 20 years ago. We may need to adjust and revise our way of thinking. Demographic reports indicate that the largest population of economically disadvantaged and minority students are and will continue to enter our schools in larger and larger numbers in the next decade and that we are not prepared to offer these children the education they need and deserve. This represents a waste of natural resources, as well as a system of subtle discrimination which is aimed at groups with the fewest resources and very little political influence. We are in a position to see that this kind of discrimination does not continue in the future.

As educators and leaders in our field, we are often blamed for the ills of society - not only are we blamed for illiteracy, we are charged to provide the children of this country with parental guidance, moral values, motivation to succeed, and more. We are expected to teach and fill in where the home leaves off. We may not be able to fulfill all of these needs. Yet, we should be able to assure a high quality education to all by seeing that teachers in the field are well educated, knowledgeable, caring people.

Such a charge to the public schools makes it difficult at best to offer high quality education, given the talent and resources at our disposal at the present time. But don't despair just remember what Will Rogers said: " The schools ain't what they used to be and they never was." I am sure that all of us in this room have a vision that will make the schools what they "never was."

Rather than speak to the general ills of the schools let me focus on the crises that we as mathematics educators must resolve in the next decade if we are to assure high quality mathematics education in our schools. In our work as the primary educators of teachers in mathematics we are presently treating symptoms of an illness in our society; that is a lack of bright - well educated - teachers of mathematics. In order to do a better job, we need to look below the surface, rather than focus on "the tip of the iceberg." To do this, we need to consider the various crises which impact on the training and retraining of teachers in the natural sciences. At present and in the years to come, we face the CREDIBILITY CRISIS - THE QUALITY CRISIS - THE PRESTIGE CRISIS - THE SALARY CRISIS - THE FUNDING CRISIS - THE COMPETITION AND RETIREMENT CRISIS - THE CONTINUITY CRISIS - THE APATHY CRISIS - AND THE TALENT CRISIS.

In this paper, I intend to define some of the problems that we face today in teacher training and upgrading in the natural sciences. I will then try to point to some solutions that exist and some that need to be put in place. Since this paper is limited in space and scope, a bibliography is provided for the reader since I refer to few sources in the body of the paper.

THE PROBLEMS:

1. First we face a crises of confidence - John Q. Public does not believe that our children are getting the best teachers! The truth is that this perception is correct! Twenty years ago the brightest and most talented people who entered education were women.

I am sure that some of you in the audience would argue that this is still true. Many of the women who would have entered science and mathematics teaching today are planning to become engineers, lawyers, medical doctors, mathematicians, or scientists. The National Science Teachers Association reported in 1981-82 that there was a 77% drop in the number of mathematics teachers trained between 1971 and 1980. A similar drop of 65% was reported for science teachers. Another statistic mentioned in that report indicated that there were only 32 graduating seniors who planned to teach mathematics in the state of New York in 1982 and 20 in the state of Texas. We might ask the question - How good are those 52 teachers and are they still in the field?

2. Next we face the crisis of prestige - Ask yourself the question "Would I encourage my children or grandchildren to become public school teachers?" I will not ask you to raise your hands and let me know how many would encourage their own flesh and blood to become teachers. I have asked myself, my colleagues, and my students this question. The answer has been clear. Salaries are too low and people do not respect teachers. Why should one spend four years in college at great expense, continue to go to school for a masters or even a doctorate and find that friends and the general public lack respect for their chosen profession?

Kilpatrick and Wilson suggest that the shortage is a reflection of the negative attitude society and the Education Community has toward mathematics, teaching and teachers. Current proposals fail to make teaching an "attractive profession which can attarct and retain superior teachers."

3. Related to the prestige crisis is the salary crisis. The average teacher in the United States is paid about $23,000.00 a year. The NEA reported that teachers lost $1700.00 in constant dollars between the years 1971 and 1983 and the average salary was $22,000.00. Another source reported in 1984 that the range of average salaries for teachers was between $15,895 and $28,877. The average age of teachers today is 39. How does the average salary compare with that of other professionals who have reached the peak of their career at this age? How do professionals in the field react to the question, "If you could choose a career again, would you teach?"

A 1966 survey showed that over half would re-select teaching as a career. In 1983 a repeat of the same survey showed that figure had dropped below 25%. Much of the reason for this is lack of prestige and money.

4. Consider next the funding crisis - the cost of a college degree is as little as $9,000.00 and as costly as $65,000.00. Few scholarships exist and those designed for teachers are usually limited to $2,500.00 a year. The top universities in this country charge $16,000.00 to $18,000.00 per year for room, board, tuition and books. Funding for retraining and upgrading is available and that may increase. However, this administration has cut back on various sources of scholarship, loan and aide. Would you invest $40,000.00 to $60,000.00 in a career which guarantees low pay and little prestige, especially if you knew that you had to find a summer job and moonlight to feed your family? I would guess that the answer would be no for highly motivated, intelligent individuals who demand excellence of themselves and others. Does this mean that less bright people will and do choose teaching? It seems to be the case today, and this reinforces the notion that teachers are not as well educated as other professionals!

5. Given that a great number of young and talented women enter the profession, get married, and raise families we have the continuity crisis. That is, many of the women who teach will take a maternity leave while others choose to stay home for many years and raise their families. This gives rise to the question of day care. We have few good day care facilities in the schools. Certainly schools more than industry could provide excellent day care for this talented group of women who may be lost to the profession for ten years and then may come back at a time when their training and knowledge is out of date. The time and cost of retraining is a burden placed on the returning teacher, with little or no support from the government, the profession, or the schools. It might be more efficient and cheaper to finance quality day care.

6. The apathy crisis - Teachers are seldom enlisted in the task of designing curriculum for the very children whom they teach. This is one of the things that makes teachers feel powerless and apathetic.

Kilpatrick and Wilson point to the "top down" manner in which curriculum is developed in the schools as a cause of apathy. They further suggest that input from mathematics teachers is ignored or minimized.

7. The exit and retirement crisis - We know that a great number of teachers leave the field for industry. Most leave in the first five to seven years. Many of the others who leave the profession do so because they have retrained, especially in computer technology. This group has been seduced by industry. In addition to this we expect another crisis to emerge, namely the retirement crisis. We know that a large number of teachers entered the profession in the 1940's. These experienced and talented teachers will retire in the next five years. Given the increased graduation requirements which have been mandated in most states, we will be unable to find certified and qualified teachers for our classrooms. It is ironic that we will face a large shortage at a time when the profession is trying to raise standards. I am sure that you all know what this will do to these efforts.

Hawley indicates the importance of addressing the attrition crisis. His suggestion is to improve the quality of the workplace as a means of keeping experienced teachers and of attracting teachers back to the profession.

THE SOLUTIONS:

If we are to solve or partially solve the problem of supplying high quality mathemtics and science teachers for the classrooms of this country, we need to consider all of the suggestions which follow as a starting point only. We all need to be creative in our approach to the problems which face us, and pose more creative and practical solutions now and in the future. The suggestions listed here may only serve to melt the tip of the iceberg, but they offered as a beginning.

1. PROVIDE SCHOLARSHIPS AND GUARANTEE JOBS TO THE VERY BRIGHTEST PEOPLE IF THEY ARE WILLING TO TEACH MATHEMATICS OR SCIENCE.

2. FINANCE GOOD DAYCARE AS A BENEFIT SO THAT WE DO NOT LOSE LARGE NUMBERS OF EXPERIENCED TEACHERS.

3. OFFER SCHOLARSHIPS AND/OR LOAN FORGIVENESS TO PEOPLE WHO ARE WILLING TO RETRAIN INTO MATHEMATICS OR SCIENCE AND THE SAME TO UPGRADE TEACHERS ALREADY IN THE CLASSROOM.

4. OFFER MERIT BASED ON BOTH TEACHING QUALITY AND PROFESSIONAL GROWTH FOR ALL TEACHERS AND BONUSES FOR TEACHERS IN AREAS OF SHORTAGE.

5. SUPPORT AND ENCOURAGE TRAVEL TO PROFESSIONAL CONFERENCES FOR ALL TEACHERS.

6. RETRAIN THE BEST AND BRIGHTEST TEACHERS INTO AREAS OF SHORTAGE AND PAY ALL EXPENSES.

7. DEVELOP PARTNERSHIPS WITH THE COLLEGES AND UNIVERSITIES. IF THEY WON'T COME TO YOU THEN YOU SHOULD APPROACH THEM.

8. MAKE SALARIES COMPETETIVE WITH THOSE IN INDUSTRY AND CONTRACT WITH TEACHERS FOR 11 MONTHS SO THEY CAN PLAN, DESIGN CURRICULUM, AND CUT DOWN ON MOONLIGHTING.

9. INVOLVE TEACHERS IN DECISION MAKING SO THAT THEY DO NOT BECOME APATHETIC.

BY RECRUITING AND REWARDING THE BRIGHTEST PEOPLE, WE WILL EVENTUALLY RAISE THE SELF IMAGE AND PUBLIC IMAGE OF TEACHERS IN THE FIELD. WE KNOW THAT MANY PEOPLE WILL NOT TEACH BECAUSE THEY DO NOT SEE TEACHING AS A VALUED PROFESSION. IF WE AS PROFESSIONALS DO NOT LOBBY STRONGLY FOR THESE CHANGES, WE WILL NOT BE ABLE TO SOLVE SOME OF THE PROBLEMS WE FACE. I SEE THIS CRISIS AS VITAL TO OUR NATIONAL SECURITY. ONE MISSILE A YEAR WOULD PAY FOR ALL THAT IS NEEDED.

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With sincere appreciation to my Graduate Assistant, Margie Page, for the extensive research she has done in the area of mathematics and science education which has been helpful in developing this paper and other papers intended to disseminate information on mathematics retraining programs.

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RETRAINING OF MATHEMATICS TEACHERS BY PEERS

BY

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The concept of training qualified teachers to teach mathematics fascinated me from the first time I heard about the Long Island Project. Without considering myself as a potential trainer, I openly stated that I felt teachers presently teaching at the high school level and college level, instead of college professors, should do the teaching. With a growing need for math teachers in Portland, the Portland School System felt we should start to retrain teachers. At this point, I suggested that I be one of two Portland teachers to teach six courses for the "Long Island Project."

In August, 1985, I started the Refresher Math Course and continued through precalculus. I finished in March, 1986 and Dr. Larry Wheeler started his sequence of courses including calculus. In the spring of 1987, I will teach the last course and hopefully tie the two years together. Dr. Wheeler and I brought much experience to this program. I have taught grades seven through twelve from basic math through calculus and since 1967 I have taught a variety of courses for the University of Maine. Dr. Wheeler teaches many upper level courses and has extensive experience at the college level.

Because I felt it vital to receive input from the project participants, I asked several to critique the project. The following points were made:

1) The instructor is easily accessible.

2) Someone who is presently teaching high school students has a much better idea of just what training is needed to be a math teacher.

3) If a participant has a problem, he could get help immediately.

4) A fellow teacher is familiar with the local school calendar and can adjust the class scheduling to accomodate each special situation that might arise.

5) LIMP instructors know the reality of the classroom and the advice that they give is based on their experience in a classroom of 30 students with different ability and motivation.

6) Their advice is practical and they are less concerned with educational jargon and theory than with what works daily in the classroom.

7) Equally important is they recognize they are not creating mathematics but retraining teachers to teach math. Most school systems do not need ten calculus teachers, but they do need teachers who have a good understanding of math and its application to daily life.

8) An experienced secondary math teacher can teach not only the content but the way to teach the content.

In closing, I would like to add that this project has been most enjoyable. I feel retraining teachers to teach math is a viable solution to the problem of a shortage of math teachers.

Dorothy F. Kelleher teaches mathematics at Deering High School, Portland, Maine and coaches the Deering Math Team. She teaches part-time at the University in Portland's Project for retraining teachers, sponsored by Long Island University. She received a B.A. in mathematics from the University of Maine at Orono in 1967 and a M.A. in mathematics from Bowdoin College in Brunswick in 1972. She is married to Dennis J. Kelleher, a software engineer with Innovative Software and a bridge columnist. She has one son, Brett. Her hobby is bridge.

STRATEGIES FOR UNIVERSITY AND SCHOOL SYSTEM COLLABORATION

BY

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Introduction

The in-service education of teachers has undergone a period of change and redirection in the past ten years. One of the most significant changes has been the increased responsibility school systems and teachers have assumed in the design and implementation of in-service programs. More recently, dissatisfaction with the current status of education has had an impact on the nature and content of in-service activities. National reports on education (e.g. A Nation at Risk, NCTM's An Agenda for Action) have called for a reorientation of curriculum content to reflect a stronger emphasis on basic skills in general, and in mathematics education, a more defined focus on problem solving and computer-based skills.

Both, the change in teacher role concerning in-service and the demands for curriculum change in mathematics, have implications for the way in-service activities are designed and implemented in the next decade. This paper will present a general approach to the planning of in-service activities in mathematics which addresses these latter factors. To provide the necessary background for related issues, the paper will also deal with a discussion of the need for in-service education in mathematics.

In-service education in mathematics: Terms, rationale and issues

The term in-service education has assumed a variety of meanings. The meanings range from a planned degree-program to the study of a topic of interest by a teacher. In-service education has been formally defined as "... commonly understood to include the collegiate and school-based programs of professional study and work in which the teacher is involved after he/she has been certified and employed ... These include institutes, workshops, and after-school and summer activities" (Cogan, 1975, p.220). More recently, in-service activities have been subsumed under the term staff development. This term denotes the shift in direction from higher education institutions to school districts for the initiation, planning, implementation and evaluation of in-service programs. Another term which has been used to indicate in-service activities is that of teacher retraining. With the need for larger numbers of mathematics teachers, attempts have been made to recruit and "train" educators (outside of mathematics) and non-educators alike into programs which will provide for them the content knowledge and skills to teach mathematics.

The forms in which in-service activities are delivered to teachers are as varied as the terms which are being used to label such activities. In-service may be provided to teachers through one or a combination of one or more of the following - short courses and workshops, contracted training

of teachers and production of materials, college-based courses/degree programs, "clinical" supervision of teachers with a consultant, academic credit awarded for attending/participating in professional conferences, summer institutes, and short term seminars on specific topics. As can be seen, the list is only limited by the creativity and resources of the individuals and agencies involved in the planning and implementation of the activities. The duration of the in-service also can range from a "one-shot" workshop to a long range (one/two year) program of studies.

What is the basic reason for having an in-service program in mathematics? In a general sense, it has been expressed as follows:

> Maintaining and improving the competency of teachers is perhaps the most important factor in achieving better education in the schools. Education is a process of growth that builds on, and profits from, experience. Teachers of mathematics are not immune to this essential characteristic of educational growth. Thus, the significance of in-service education for maintaining and improving the competency of every mathematics teacher can hardly be overstated (Downs, 1977).

There are a number of other arguments, in addition to the general one presented above, which provide a rationale for in-service education for mathematics teachers. There is a need to strengthen and/or upgrade the content knowledge of teachers, as well as to prepare teachers from other fields to teach mathematics. Curriculum changes have mandated that in-service activities address the teaching of problem

solving skills, and the integration of computers into the mathematics instructional process. Legislative mandates have forced teachers to implement comprehensive student assessment and reporting. A concern for the mathematics education of students historically underrepresented in mathematics (i.e. women and minorities), has brought about the need for the implementation of programs to address this problem. These are areas, which in the past, were not addressed by in-service activities or lacked the depth necessary to give teachers the required knowledge and skills. Finally, it has been said that the most compelling reason for having in-service education is that teachers have strongly expressed a desire to be ivolved in such activities.

There are a number of questions or issues which confront in-service educators as they plan activities for mathematics teachers. The reason why these issues exist can be attributed to the nature of mathematics in-service education during the latter part of the 1960's and the early '70s. During this time attempts were made to revolutionize the content and teaching of mathematics. In-service activities during this period were characterized by strong funding support from federal agencies and predominant implementation by institutions of higher education.

The questions or issues to be resolved are as follows:

1. Should the content of the in-service program address mathematical knowledge, teaching methodology or should it be balanced between the two areas?

The programs of the sixties favored increasing teachers' mathematical knowledge over increasing their skills in teaching methodology. One outcome of this emphasis on content over pedagogy was the questioning by teachers of the usefulness and the benefits they received from in-service education. Teachers felt that while the programs gave them a thorough content preparation, they felt inadequate in dealing with the problems they faced in the classroom. During the latter part of the seventies, as a reaction to this concern, in-service programs in mathematics dealt primarily with methodological topics - diagnostic/prescriptive instruction, dealing with academically heterogeneous student populations, and strategies for dealing with remedial/gifted students. With the advent of recent reports critical of education, the pendulum appears to be swinging in the direction of mathematical content as the focus of in-service activities. This time it appears that methodological issues may be considered in the context of mathematical topics.

2. Who should be responsible for the funding of in-service programs?

The predominant role federal agencies played in the funding of in-service programs almost died during the latter part of the seventies. School districts picked up some of

the expense in the "staff development" of teachers, but not to the same degree as it had been experienced earlier. In recent years state legislatures have appropriated monies for teacher in-service programs and districts have also contributed their "fair share". Federal agencies appear to be funding some teacher in-service efforts in mathematics, but not at the same level characteristic of the sixties. Overall, it appears that the burden for financing in-service activities rests with the state or local school district, and many times this is done to comply with some legislated mandate.

3. Who should be responsible for the design and implementation of in-service programs?

One of the outcomes of the strong reliance on university-based programs was a feeling among teachers that their in-service education was "institutional" in nature, completely disregarding to their own needs and interests. This created in some teachers the inability to identify their own weaknesses and then to seek ways to overcome those weaknesses. In the latter part of the seventies and early eighties the concept of "teacher centers" became common in in-service education. The principal idea was to design and implement in-service activities based on teachers' and districts' needs rather than following a university-based program. The basic underlying assumption was to have teachers in control of their own in-service experiences.

This approach was reinforced by funding from state agencies (e.g. Florida), and it appears today to be a common approach to teacher in-service. In many states institutions of higher education have collaborated in the formation of the teacher centers and in the delivery of programs which are part of the total offered by the centers.

In summary, it appears that for in-service in mathematics, (a) attempts have been made to reach a balance between mathematics knowledge and teaching methodology in its content, (b) the state or local education agency plays a predominant role in program funding, as well as the planning and coordination of the activities. These present characteristics of in-service education have implications for the nature of the relationship that must exist for university and school system collaboration in the continuing education of mathematics teachers.

Basic premises for university/school system collaboration

The major premise underlying any kind of in-service program is that "good" in-service/retraining/continuing education activities do improve teacher performance and student learning. This raises the question of what constitutes a "good" in-service program. As we know, any educational enterprise is influenced by a variety of factors. There are many factors which can be identified as contributors to the success of an in-service activity.

Rowan, et al (1977) cite the following factors as contributing to the effectiveness of in-service activities:

1. identification of needs and cooperative planning as an integral part of the program design process;
2. provision of incentives for teachers to participate in the in-service activities such as release time, adequate funding, award of credits toward renewal of credentials/graduate degree, and stipends;
3. team approach orientation toward the in-service activities to give a sense of program "ownership";
4. appropriate balance of mathematical content and teaching methodology based on teacher needs and educational mandates;
5. relevancy of content activities to daily classroom instruction, so that teachers can explore instructional strategies and/or develop materials which can be immediately used in the classroom;
6. continuing evaluation of in-service programs, with a provision for revision of activities;
7. regular and appropriate follow-up in the classroom;
8. integration of individual in-service activities into a cohesive program so teachers can benefit from long range objectives.

The role of colleges and universities

The previous discussion concerning issues and characteristics of in-service education set the foundation for the role colleges and universities need to play in the design and implementation of in-service programs. It is clear that the role of the institutions of higher education has changed from one of sole responsibility for all aspects of in-service to one of "partnership" with the local education agency. Given the involvement of teachers in the process of planning in-service programs, universities have had to balance the content of the activities between theory and practice, mathematical knowledge and teaching methodology. Also, institutions of higher education have

seen the need to move away from the traditional "degree program" form of in-service education to "delivery" strategies which are more closely in accordance with district goals and teachers' needs.

A general model for university/school district collaboration

Given the factors which explain the success of in-service programs and the changing roles of institutions of higher education (IHE's) and local education agencies (LEA's), a general approach to the development and implementation of programs for mathematics teachers may consider the following conceptual framework adapted from one proposed by the Centre for Educational Research and Innovation (CERI, 1978). The framework consists of three dimensions - source of in-service activities, process necessary to design and implement the activities, and the clients who will participate in the program.

The source dimension comprises the agents and agencies responsible for the planning and implementation of the in-service program. These may include -

1. national/state/regional agencies, such as state departments of education, and state and national professional organizations;
2. local education agencies (LEA's);
3. colleges/universities;
4. teacher centers (which may be part of an LEA);
5. independent consulting firms;

6. publishing companies.

The process dimension of the framework deals with the tasks which need to be accomplished in order to carry out an in-service program from inception to completion.

TASK 1 - to determine the overall goal of the in-service program. Seven "orientations" of in-service programs are mentioned in the CERI report:

1. transitional, to update teachers with content and skills which are required because of developments in the field or new curriculum mandates (such as the in-service needed to comply with minimum state requirements in mathematics);
2. school renewal/role reorientation, necessary to change the focus of the school program to a different or innovative orientation (for example, the implementation of a "magnet" computer school);
3. context specific/role improvement, to deal with specific skills/content teachers need in order to perform more effectively or to incorporate into their instructional program new teaching strategies (such as the skills needed to teach problem solving to students);
4. personal/professional growth;
5. continuing education, possibly leading to a graduate degree or higher level credentials; and

6. career progression, related to the concept of "master teacher" within a "career ladder program" some school systems are implementing.

As can be seen, these "orientations" are not mutually exclusive nor exhaustive, but they provide an orientation to assist planners in focusing the purpose and objectives of an in-service program.

TASK 2 - to determine the cost of the program and to identify and secure sources of funding. A large percentage of in-service programs are funded by LEA's or state education agencies. Funding is also becoming available from federal agencies for summer institutes, retraining programs and materials development. It has been reported that teachers expect that "...in-service education should be provided as their due and privilege and that ... they should no have to pay for it themselves" (Osborne, 1977, p. ix). Even though this expectation is real, many teachers pursue degree granting programs for which they pay.

TASK 3 - to determine the type of reward" to be given to teachers upon successful completion of the in-service program. There are several "awards" which can be granted to teachers once they have successfully met a number of criteria for completing in-service activities. They include graduate degrees, certification, salary raises, career promotion, change in role from classroom teacher to resource professional. It is true that many in-service activities do

not carry any type of "award" and some only require teachers to be present at the sessions without having to show competencies gained as a result of the instruction. Recent concerns for accountability indicate the trend to require teachers to show some degree of competency before an "award" for completion of the program is given.

TASK 4 - to delineate roles and responsibilities for the coordination of in-service activities. It is essential that in-service programs receive input from as many sources as possible regarding content and implementation. It has been suggested that equal representation among IHE's, LEA (supervisory and administrative personnel) and teachers be involved in the planning and coordination of programs. This will assure that the professional education of teachers is related to their interests and needs and in accordance with district goals.

TASK 5 - to evaluate the in-service program. The basic purpose of the evaluation of in-service activities is to provide planners and other decision makers within the educational community with information for program decisions. It is important to evaluate not only the <u>process</u> of in-service but also the <u>products</u> of the program. "How well was the program implemented?", is as important an evaluation question as, "What did the teachers learn or what skills did they acquire as a result of the activities?".

The source and process dimensions of the framework must be integrated in such a manner that the specific needs of the clients are addressed. In this case we are referring to teachers, but it is important to differentiate the different populations of instructional, and supervisory personnel which may be involved in in-service activities. For example, elementary school teachers because of their mathematics background would probably benefit from activities different from the ones appropriate for secondary school teachers. The same case can be made about in-service programs for supervisory personnel as opposed to instructional staff. Figure 1 shows a graphic representation of the framework presented here for IHE/LEA collaboration in mathematics in-service programs.

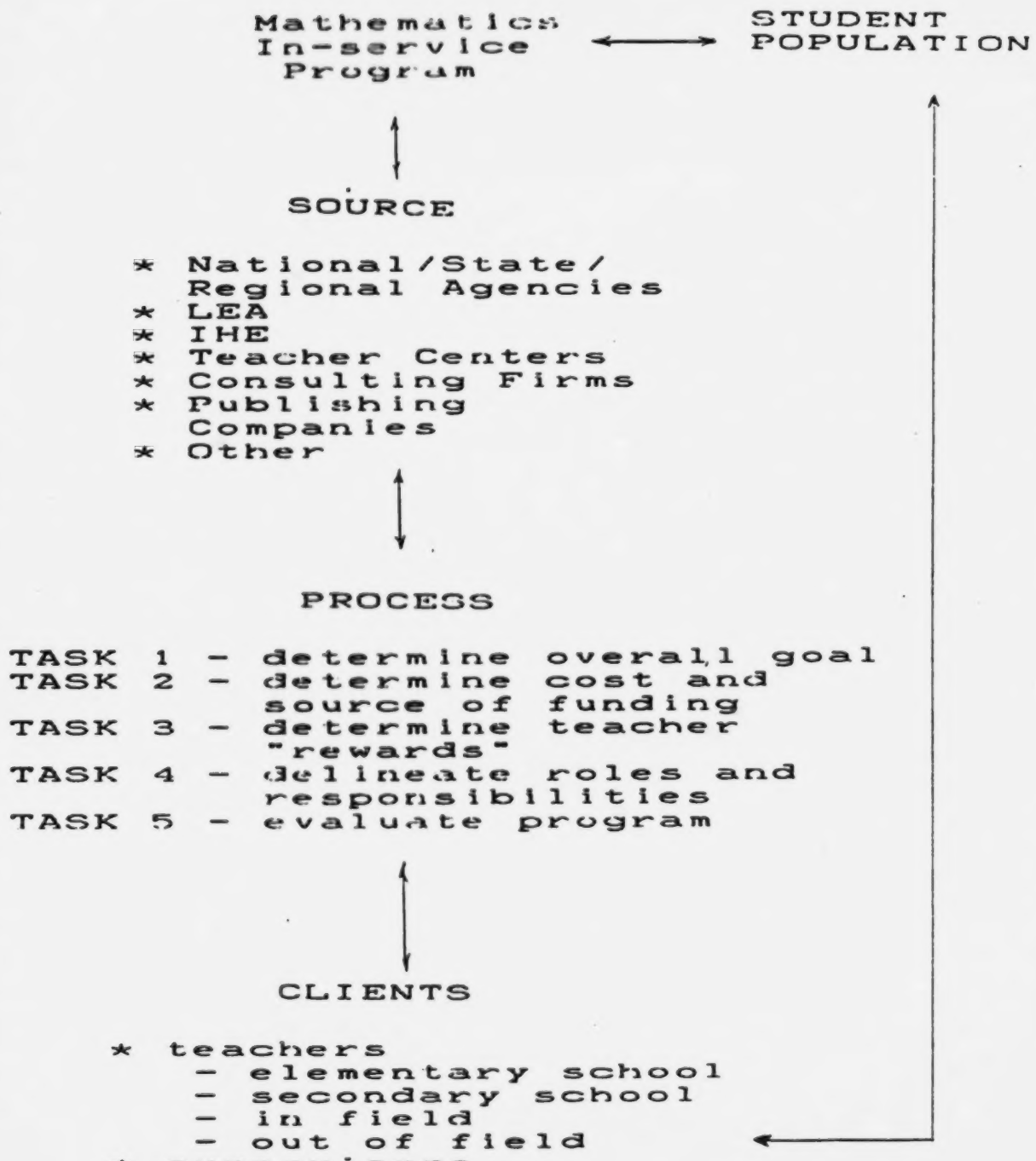
Conclusion

A nation-wide survey conducted in the late '70s (Osborne, 1977) indicated that:

(a) most teachers desire a voice in determining the nature of the in-service program in which they participate, and
(b) bad experiences reported by teachers with prior in-service education were partly the result that teachers had not shared in the decision-making process of the program.

The involvement of mathematics teachers in every aspect of the design and implementation of programs for their continuing professional development is most important.

A GENERAL MODEL



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RETRAINING TEACHERS IN MATHEMATICS: STANDARDS AND EVALUATIONS

BY

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The National Association of State Departments of Teacher Education and Certification (NASDTEC) establishes standards for programs which prepare teachers of mathematics. In this paper we will evaluate Trenton State College's Program to Retrain Teachers in Mathematics against each of the current set of seven standards. Trenton's eighteen month program offers a sequence of eight three credit graduate courses which in conjunction with passage of the National Teacher Examination specialization examination in mathematics leads to state certification to teach mathematics grades K-12. The state requirement to be certified to teach mathematics for an individual who already holds a teaching certificate in another field is 30 semester hours in mathematics plus the NTE examination noted. Each participant is required to bring 6 semester hours of college credits in mathematics to the program and when added to the 24 credits offered, the state requirement is fulfilled. The eight courses offered are listed below:

MAT 510	Survey of Mathematics
MAT 512	Applied Calculus I
MAT 514	Applied Calculus II
MAT 516	Introduction to Modern Mathematics
MAT 695	Topics in Mathematics for Secondary Teachers
MAT 530	Foundations of Geometry
MAT 560	Linear Algebra
CSC 520	Fundamentals of Computer Programming

The first five courses are modeled after the THA-MASTER program at Long Island University directed by Dr. Madeleine Long. As part of the program a two week refresher course is offered to review algebraic and geometric skills needed to begin the sequence. Additionally, each course meets almost double the normal time for graduate courses with one-half of each session using the traditional classroom lecture followed by a laboratory setting which includes individual tutorials, discussion groups, problem solving sessions and testing.

STANDARD I — The program shall require demonstrated competence in knowledge and understanding of the basic concepts of algebra (elementary functions including trigonometric), geometry (Euclidean and non-Euclidean), analytic geometry and calculus, probability, statistics, and modern algebra(linear and abstract).

In our Refresher Mathematics course the participant reviews intermediate algebra skills as well as many of the concepts of the standard plane geometry curriculum. MAT 510, Survey of Mathematics is a conventional precalculus course which includes study of the polynomial, exponential, logarithmic, and trigonometric functions as well as analytic geometry. MAT 512 and MAT 514, Applied Calculus I, II, covers the standard differential and integral calculus encountered in the typical Calculus I, II sequence found in most undergraduate programs. MAT 530, Foundations of Geometry explores Euclidean as well as non Euclidean geometries both from an axiomatic approach as well as through use of models for non Euclidean geometries. In MAT 516, Introduction to Modern Mathematics the student is introduced to abstract algebra through the study of groups, rings, and fields. A separate course MAT 560, Linear Algebra is included to provide for the inclusion of the linear algebra noted in the standard. MAT 695, Topics in Mathematics is used to teach the probability

and statistics and number theory concepts essential to teachers of mathematics. It is clear that the participant receives an extensive subject matter background that provides a thorough understanding of the nature of mathematics. This standard is fully met.

STANDARD II The program shall require demonstrated competence in understanding of standard mathematics vocabulary and symbols and of the logical principles used in mathematical proofs.

Through classroom lectures and workshop activities in all the courses, mathematics is presented as a language in which one needs to be able to read, write, and speak as a mathematician. Emphasis is placed on providing participants with the opportunity to express themselves with mathematical preciseness. Throughout the program participants are required to use correct mathematical notation. Beginning with the Courant and Robbins text used in MAT 516 the importance of symbolism, the nature of proof, and the concepts of logic are stressed. Through the remainder of the program this foundation is built upon and the students expand their ability to do proofs. By the end of the program participants have learned to logically organize and write mathematical proofs. This standard is fully met.

STANDARD III The program shall require demonstrated competence in understanding number concepts and computational algorithms, including estimation and approximation, and the use of appropriate models and manipulatives for teaching these algorithms and concepts.

Beginning with the first course and continuing throughout the program the real number system is stressed as the foundation upon which mathematics is built. Every effort is made to provide understanding of the differences and commonalities among the natural numbers, integers, rational numbers, and irrational numbers. In fact, in MAT 695 about one-half the course is devoted to number theory concepts essential to effective classroom teaching. In teaching more sophisticated algorithms an analogy is made to a standard algorithm at a less general level. For example, the process of dividing two polynomials using long division is shown to be analogous to the long division algorithm for whole numbers encountered in the elementary grades. Participants are encouraged throughout the program to estimate and approximate solutions prior to obtaining formal solutions. Since no formal methods course is offered, the program integrates methodology into the regular coursework. When a skill or concept is encountered for which models such as graphs, chalk globes, straight edge and compass or manipulatives exist, the instructor will demonstrate and in many cases provide hands on experience within the lecture. This standard is met.

STANDARD IV The program shall require demonstrated competence in understanding the intellectual, historical, and philosophical nature of mathematics, methods of applying mathematical principles to other disciplines, and the relationship of mathematics through technology to social conditions.

Throughout the program whenever new topics are introduced participants are made aware of historical developments as well as any social implications. It is standard practice in assignments to include problems which illustrate the relationship of mathematics to the arts, humanities, business, medicine and sciences. Textbooks are carefully chosen so that cultural-historical insights are not ignored but presented at suitable places in the courses. Mathematical deduction and the postulational method are discussed and used in MAT 516. This course, based on Courant and Robbins "What is Mathematics" especially satisfies this standard. Here students learn that one viewpoint of mathematics is that it arises from the attempt to solve problems related to the real world. They also learn that the pure mathematician's point of view is much different, applications are totally irrelevant and there is no need to search for them. It is sufficient simply to study mathematics for its own aesthetic value. Additionally the Geometry course emphasizes the postulational method and philosophical nature of mathematics. In the computer programming course participants enter our technological society and develop an understanding of the role of mathematics in computer science and vice-versa. This standard is met.

STANDARD V — The program shall require demonstrated competence in the selection and creation of appropriate mathematical models to solve applied problems.

Students in the program experience mathematical models in several of the courses. The most direct use of models occur in the Courant and Robbins course where one finds models constructed for groups, rings, and fields; in the Geometry course where the two major types of non-Euclidean geometries, Lobachevskian and Riemannian, are treated in detail; in Linear Algebra where matrices are used as a mathematical model for various applications, and in Computer Science where mathematical modelling is essential for problem solving. Applied problems also occur frequently in the calculus sequence with problems dealing with instantaneous rates, maxima and minima, as well as problems from the social and natural sciences. This standard is met.

STANDARD VI — The Program shall require demonstrated competence in identifying, developing and solving problems involving the application of mathematical concepts, principles, and problem-solving strategies.

In virtually all the courses a great deal of time is devoted to developing the ability to identify, articulate, and solve problems involving mathematical principals and concepts. Early in the program participants are introduced to Polya's problem solving strategies. As problems are encountered these strategies are developed and demonstrated by the instructors. Students are encouraged to employ similar strategies in their own problem solving situations. This standard is fully met.

STANDARD VII — The program shall require demonstrated competence in using calculators and computers in mathematical applications and problem solving, and using a suitable computer language to write programs.

Calculators and computers usage are integrated into the program in various ways. Participants bring to class a scientific calculator which they are encouraged to use in problem solving situations. Where appropriate both exact and approximate solutions are required to emphasize the use of the calculator as a tool in applied problems. Throughout the program calculators are also used to lead students inductively to understand mathematical concepts before offering formal proof. For example, the calculator easily leads the students to conclude:

$$\lim_{x \to 0} \frac{\sin x}{x} = 1$$

Computer usage appears in three forms: (1) computer assisted instruction, (2) problem solving and (3) PASCAL language. The college maintains a mathematics lab which is available to all participants. Within the lab there is a variety of computer assisted instructional programs for illustrating and explaining mathematical concepts. These programs are used both in a classroom setting via a projector which permits total visibility of the video display onto a large screen and individually at PC's within the lab for participants seeking additional clarification of a concept. These same computers are also used to demonstrate concepts that benefit from computer graphics such as the area under the curve in the calculus and displaying graphs of functions in the multi-variate calculus. Additionally, problem solving tasks that lend themselves to computer solution such as determing the inverse of a matrix or solving a systems equations in linear algebra are demonstrated after the participant has learned the concept in the traditional manner.

In CSC 520 participants learn to program in the PASCAL language. The course includes the use of all the standard structures available in the language including loops, arrays, subroutines, and some file processing. Participants write programs to solve more sophisticated mathematics problems. This standard is fully met.

Michael Iannone has been actively involved in teaching mathematics at the college level for the past nineteen years. He holds a B.A. from Trenton State College, a M.S. from Clarkson College, and an Ed.D. degree from Rutgers University in curriculum and instruction. He has also served administratively within his department as Assistant Chair from 1979-1984 and as Chair from 1984-present. He has also directed two very successful DHE grant programs, the "Program to Retrain Teachers in Mathematics" and the cooperative pre-college program the college conducts with the Trenton School District commonly referred to as the "TRENTON COLLEGEBOUND PROJECT." Professor Iannone will assist in selecting faculty to participate and as a consultant for the planning of content.

PRESENTATION OF CALCULUS TO RURAL AREAS THROUGH THE USE OF VIDEO-TAPE

BY

ROBERT MAIN

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PROGRAM OVERVIEW

Western Oregon State College, in 1985, became part of the THA-Master network for retraining teachers from other disciplines to teach mathematics. Western's special mission was to provide inservice training to teachers who could be considered distant learners due to the fact that many of them lived in rural areas at a sufficient distance from an institution of higher education to preclude participation in regularly scheduled classes. Even for those teachers who lived near a college or university campus, their schedules and obligations often preclude attending regularly scheduled classes.

We proposed a delivery system which features video-taped presentations. We focused on the calculus part of the THA-Master program because:

1. Calculus has the reputation of being difficult.
2. Calculus classes meet more often per week than the other courses required for mathematics certification.
3. The content of a typical calculus sequence cannot be readily covered during one or two summers.

In summary, these are the reasons that calculus has often been the stumbling block for mathematics certification and, hence, the reason for our focus.

Initially, it was planned to video-tape an on campus calculus course and utilize our Instant-Replay system. This is a system devised at Western Oregon, which video-tapes on campus classes and disseminates the tapes to approximately 50 sites throughout the state. The Instant Replay system will be discussed in greater depth in the second section.

The video-taping of an on campus calculus class proved to be infeasible due to:

1. Differences between the THA-Master philosophy and our standard calculus sequence.
2. The cost of additional presentations needed to bring our course in line with THA-Master.
3. The release time for the staff to do the course developement necessary was beyond the scope of the grant.

Hence a search was initiated for a commercially available calculus video-taped presentation. Several were considered and the ITV Calculus sequence produced by the Maryland Deptartment of Education was purchased. The ITV Calculus was chosen because of its affinity with the THA-Master philosophy, its adaptablity for teacher training and its ease of use in the Instant-Replay format. A student workbook and test booklet accompany the tapes. The one major drawback to the ITV Calculus is that it is keyed to Thomas' Calculus Text which has an engineering - science orentation.

A second difficulty encountered was that, although over 20 students in the summer of 1985 expressed interest in taking the calculus course by the fall the number had dwindled to 11. This reduced the potential number of site locations and the cost effectiveness of the program.

One of the key dimensions of the THA-Master program, in our opinion, is the tutorial sessions built into its format. We wished to maintain this dimension in

our design, so potential tutors were contacted at four sites in Oregon. Of the 11 students mentioned above 5 were able to attend at the Salem site, 4 at the Bend site, and 2 students were to work on their own with the help of a local tutor. The program was structured so that one evening per week the students would meet at a site, view the tapes, discuss their problems and gets help from their tutor. They could view the tapes more frequently if they could arrange their schedules appropriately. (Some students commuted 30-40 miles to their sites.) As the program evolved at the Bend site,. (located on the Central Oregon Community Campus), the tapes were duplicated and the students were able to take them home and play them on their schools' or their own VCRs. This became a definite plus for these students since they were able then to use the tapes in three different ways:

1. To introduce a given concept.
2. To intensively study a concept. Portions of a tape could be replayed until the concept was mastered. A student was free to stop the tape and refer to a text or the workbook or to do pencil and paper work and then return to the tape and rerun it if necessary.
3. As a final review of a concept.

The students worked individually between meetings utilizing the tapes, workbook, and calculus texts. The students would also call each other and their tutor at times to get needed feedback.

The ITV Calculus is organized into 7 units which are divided into 90 lessons. The format is structured so that two half hour TV lessons are followed by one individualized study lesson. The last lesson in each unit is a test over the material of the unit. The TV lessons are coordinated with the workbook. The workbook provides an outline of the TV lessons, comments upon the lessons plus examples and exercises. The individualized follow-up lessons are also in the workbook. (See the appendix for an overview of the lesson content in the ITV Calculus course.) The stated objectives of the ITV Calculus are:

1. To integrate TV instruction and classroom instruction, with each complementing the other.
2. To maximize the effectiveness of the 8000-9000 classroom minutes students spend in learning calculus.
3. To utilize teaching techniques that emphasize visualization and logical development of concepts and their applications.
4. To develop skills and ingenuity in problem analysis and problem solving.
5. To interrelate algebra, geometry, trigonometry and differential and integral calculus.
6. To establish clear, intuitive interpretations of the principal calculus concepts.
7. To convey the spirit and methods of proof of differential and integral calculus.

The strengths of the ITV-Calculus according to the students were: it was well organized, each lesson and each presentation was carefully done, history of mathematics was part of the content, and the visual material was excellent. For example in discussing the properties of a parabola a radio telescope was shown and a lathe was used to illustrate surfaces of revolution. Its weaknesses were the conceptual gaps in the presentation, the lack of possible feedback, and its dependence upon the Thomas text.

The students were expected to do 2-4 lessons per week. The logistics of keeping the students coordinated and moving along at a reasonable rate was the responsibility of the site tutors. They had the flexibility of adjusting the schedule and pace to suit the students' needs.

The students who participated in the course came from various areas throughout Oregon. Some lived in large communities of twenty to one hundred thousand population. Others lived in smaller communities of a few hundred at varying distances from large population centers. One student was not able to participate because he lived in a small community too far away from any tutorial help. One of the participants teaches in the high school in Prineville, the county seat of Crook county. Crook county has a population of 13,000 and a total area of approximately 3,000 sq. mi. its primary industries are agriculture (cattle ranching) and lumber. Prinevilles' population is 3,200, and the high school has 720 students with 4 mathematics teachers. Some of the students live as far away as 55 miles from the school. This participant commuted 40 miles each way to participate in the program.

Because of the distances to a population center, two students attempted to do the program on their own with the help of a local tutor. These students were unable to complete the first half of the course. Eight of the remaining students sucessfully completed half of the course; covering differentiaton, applications of differentiation and an introduction to integration. This completes the requirements for Basic Mathematics certification in Oregon. Three students completed the entire course and two have attained Advanced Mathematics Certification. These two students took courses at another university sucessfully competing with engineering and science students in linear algebra and probability.

INSTANT REPLAY

The Instant Replay system was developed in 1978 at Western (Then Oregon College of Education) to help solve the problem of the distant learner. The goals of the program as stated in Developing Graduate Non-traditional Programs by Dori Beeks are to: "1) allow students to schedule courses at convenient times, 2) provide courses which meet certain requirements for degrees and teaching certificates, 3) reduce the total cost of educational services by reducing the commuting expenses, 4) offer courses which are synchronized with regular summer session schedules so that the total time for degree or certification completion is reduced, and 5) offer these opportunities in remote geographic areas of the state to students who reside in areas where other programs are not accessible."

She goes on to state: "Viewing sites for the targeted group of students are established on college campuses, communmity colleges, educational service districts, libraries and other conveniently located and well staffed community centers throughout the state.... Each center has a coordinator who oversees the equipment and schedules viewing sessions at the convenience of the student involved at that site."

By video-taping live classes the interacton and feedback which is often part of the classroom procedures is captured and viewable by the distant learner. This helps to compensate for the fact that he or she is not physically present. An 800 telephone number is provided and regularly scheduled office hours are

arranged for the instructors so that each student can get their questions answered.

Mrs. Beeks states: "Each student, in addition to viewing the tapes weekly, receives a text, course outline and other printed materials and examinations related to the course. After each student has viewed the tape of a particular week, those tapes are returned to the college and used again. Since the viewing of the video tapes occurs after the live tapes are made, Instant Replay students complete a course and have grades assigned in the following quarter."

Research has shown that Instant Replay students do as well on evaluation instruments as their on campus counterparts. The major drawback to the system is financial. The cost of producing, duplicating, and mailing the tapes plus the instructional and administrative costs make Instant Replay an expensive program to maintain. For this reason large enrollment classes are the only ones which are cost effective.

The THA-Master calculus was different from the typical Instant Replay course in several significant ways:

1. Small enrollment,
2. Small group tutorial sessions,
3. The utilization of tutors at each site,
4. The use of commercially produced tapes which were reproduced at WOSC and at local sites,
5. The students did not follow the same course outline or compete with the on campus students for their grades.

PEDAGOGICAL CONSIDERATIONS

Benjamin Bloom states in chapter 1 of Schools, Society and Mastery Learning that "There are now many versions of mastery learning in existence. All begin with the notion that most students can attain a high level of learning capability if instruction is approached systematically, if students are helped when and where they have learning difficulties, if they are given sufficient time to achieve mastery and if there is some clear criterion of what constitutes mastery." Mastery is usually defined as attainment of a high level of achievement on evaluation instruments covering the course objectives. The objectives of the ITV Calculus, although not stated in behavioristic terms, are given in the outlines of each section in the workbook and then taught to through the tapes, examples and problems. The unit tests clearly cover these objectives. The students taking the ITV Calculus averaged 92.0 through the first four units. The proceedures developed in utilizing the ITV Calculus in the Instant Replay format approximates a mastery learning strategy. These procedures combine aspects of Bloom's Learning for Mastery Strategy, Keller's Personalized System of Instruction and Postlethwait's Audio-tutorial Approach to Instruction, (see chapter 2 of of Block's Schools, Society and Mastery Learning, where the first two of these strategies are compared). Let's take a look at the procedures the students and the format which evolved from a pedagogical, stancpoint.

First let us consider the characteristics of students:

1. They all had teacher training and experience.
2. They were more mature than the typical calculus student: most were in their early thirties.

3. They were highly motivated.
4. Their prerequisite skills were lacking in some areas. Although the students had some common background many of their algebraic and computational skills were being recalled from their own high school training in mathematics or from the mathematics courses they had recently taught. Hence in some skill areas necessary for sucess in calculus they were operating at the concrete operational or even at the pre-operational level. (See Piaget's stage-dependent theory of learning.)

The last two characteristics were of particular significance. These students were able to bridge the gap between their skill level and the level necessary for sucess in calculus because of several factors, one of the major ones being that they were highly motivated.

Farrell and Farmer in their book Systematic Instruction in Mathematics state that "the heart of systematic instruction is feedback". The operational definition of feedback given is "any information, communicated to teacher or student, verbal or nonverbal, on the results of instruction." Feedback in the Instant Replay format is a definite problem. It is difficult for the distant learner to obtain the feedback when needed even with the 800 telephone number available. Feedback for students in calculus is crucial, it should be available on a daily basis. The choice of instructional mode is critical in determining the amount of feedback which can take place, and the TV-workbook format for the distant learner does not allow for adequate feedback.

Piaget's stage-independent theory of learning states that learning takes place through interaction and adaptation of the learner. Farrell and Farmer conclude: "The major implication of the constructs of interaction and adaptation seems to be the need to encourage an active learner and the need to individualize.... Nowhere was it suggested that 'individualize' equals 'learn alone.' In fact, Piagetian theory presents some strong evidence against the efficacy of 'working alone' as the most profitable way of interacting with reality."

Farrell and Farmer, in discussing planning in chapter 6, go on to point out that the central task of the teacher is to insure that meaningful learning takes place. "Thus, new content becomes meaningful to the extent that it is substantively (nonarbitrarily) related to ideas already existing in the cognitive structure of the learner." But meaning is also a function of the needs of the student. If he perceives that he "needs" to know the content of the course it endues these concepts with meaning. It is much easier to learn a concept if you believe that you need to know it; you look for tie-ins with concepts and skills you already have mastered.

Through serendipity, the THA-Master calculus program evolved into a format which takes into account these various aspects of learning theory. To review:

1. The students were mature and highly motivated but lacked some prerequisite skills.
2. Systematic Instruction was provided through the ITV Calculus Program.
3. Feedback and corrective procedures must be provided for in any well conceived learning system.

4. The ITV Calculus program in the Instant Replay format was not adequate in providing remediation, feedback or corrective proceedures for distant learners.
5. Time to achieve mastery must be provided.
6. For learning to be effective the concepts to be learned must be meaningful. This is a function of prior knowledge and motivation.

Hence the key dimension of the program was the weekly tutorial session, and the key to its success were the tutors. The tutors could better be described as adjunct faculty. During these sessions the feedback and corrective procedures were provided. Errors were pointed out and review and practice of prerequisite skills were provided. Typically, the students arrived at these sessions after a week of frustration, bringing with them lists of questions both from the tapes and the workbook. Frequently they were all having the same or similar difficulties. When they were able to overcome these difficulties, they gained confidence not only from the knowledge but also from the shared experience. They seemed to develop an esprit de corps; they acted as a support group for each other. The tutors were able to bridge the gap between the students' background and the content to be mastered. They were also able to expand upon the concepts being presented by showing related examples and applications. The students were able to provide the necessary time between sessions to practice and to interact with the tapes. (Some feedback occurred through this interaction.) Finally the tutors were able to sooth feelings, provide positive strokes, and help restore their high level of motivation for the next week's work. In preparation for the comming week they were often able to anticipate difficulties and to prepare the students for the next lessons.

Careful selection of tutors is second only to the level of motivation and background of the students in determining the success of this program. The four characteristics which seemed to determine whether a tutor would be successful were:

1. Knowledge of the subject matter,
2. Teaching experience,
3. Flexibility and patience, and
4. Empathy with the problems of the student, not only in terms of the content, but also in terms of the distant learner in a strange and experimental learning environment.

Of the four tutors initially chosen one did not get a chance to work in the program through no fault of her own, one contributed substantially to the failure of one of the independent study students, and the other two were preeminently successful, in my opinion. These two had the four characteristics listed above. They were able to anticipate the students' problems, help them over the rough spots and prepare them for what they were to encounter next.

CONCLUSIONS AND FUTURE DIRECTIONS

An ideal inservice TV program would have the following features:

1. The tapes would have a <u>branching format</u> where the supplementary material would cover remedial concepts and points of common difficulty as well as enrichment material. These tapes could be locally produced.
2. A <u>supplemental manual</u> containing material related to the supplementary tapes would be provided for the students. This manual

would contain further examples. It should be tied to a general text. This could be accomplished by providing a table of concepts keyed to appropriate chapter and page number in current texts. Important considerations in choosing these texts are that they should have an accompanying student solutions manual and should agree with the THA-Master philosophy.

3. The tapes should be copyable at each site and each student should be able to take them home or to his school in order to study them intensively.

4. Small groups of students should be able to meet at each site with carefully selected tutors.

The above suggestions in my opinion would alleviate many of the current problems with the THA-Master calculus as taught in the Instant Replay format. But, to actually make it a viable program, it must be expanded to include more students from wider audiences. I believe that there are many adult learners in Oregon and elsewhere who would profit from this type of learning experience. However, the program needs promotional work as well as the changes cited above. Therefore, funds should be sought in the future to: 1) produce the supplementary tapes including the needed course developement, 2) produce the supplementary manual, and 3) promote the program.

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Dr. Robert Main attended Monmouth College in Illinois to begin his college education, but transferred to Oregon State University where he pursued a Bachelors and Masters in Science-Education. He also attended two summer institutes in Physics at the University of Washington. Dr. Main received his Ph.D. from Oregon State in mathematics in 1970. Prior to that, he had been a secondary science and mathematics teacher in Vale and Corvallis, Oregon. He has been on the staff at Western Oregon State College for 18 years and has been Chairman of the Mathematics Department for 10 of the last 13 years. This year Dr. Main is on sabbatical, extending and deepening his knowledge in his field of geometry.

PROGRAMMATIC ASPECTS OF THA-MASTER AT LONG ISLAND UNIVERSITY

1977 - 1986

BY

SHELDON PASNER

and

MADELEINE J. LONG

All of the mathematics courses are geared towards training the participant to become a teacher of secondary mathematics rather than a research mathematician. Although the stress in the treatment of many areas is different, the mathematical topics covered are explored thoroughly. The purpose of the program is to train the prospective teacher of secondary school mathematics to fully understand fundamental and critical concepts and topic areas, and how to best present them to high school mathematics classes. Motivations, pivotal questions and practical applications (especially those that would be of interest to a high school student) are an integral part of the curriculum. Instructors seek to have students understand a topic in relationship to its place in the New York State high school mathematics curriculum and to consider some of the following educational factors:

- the overall philosophy of the "new" New York State three year sequential math curriculum
- the proper sequence of topics to be taught in any given one-year course
- the relative importance of any given topic in relation to the whole course

Even though the calculus is not a required high school subject, a thorough study of it by the THA-MASTER students enables them to understand the structure and power of mathematics. In addition, it serves to reinforce and sharpen algebraic skills and geometric knowledge, to fulfill the New York State course requirements and provide the student with the mathematical background and skills necessary to pass the New York City secondary school mathematics license exam. Interestingly, THA-MASTER required the Calculus as early as 1977, while New York State did not require it for certification until 1980.

Method of Instruction

A separate lecture and workshop composed of instruction given by two different instructors, a college professor and an outstanding high school mathematics teacher, has met with a great degree of success. Lecture and workshop can be characterized as follows:

A. Lecture Session - 3 hours, 10 Sessions per Course

- the instructor introduces part of a new topic
- theory is explained and proofs of certain mathematical theorems are derived
- model and illustrative examples are given and explained -text readings and homework examples are assigned
- applications to other disciplines are discussed

B. Workshop Session - 3 hours per Course

- new work previously taught is reexamined
- topics are explained from a non-theoretical viewpoint -

a "plain English" simplified explanation is given with illustrative examples

- alternate methods of solution are encouraged
- large degree of student participation is evident -algebraic skills are stressed along with increasing the student's mathematical knowledge
- suggested techniques and examples to use for motivating a high school mathematics class are given
- extra problems are given and explained in class
- reinforcement of previous topics is an integral part of each session. At all times the student maintains awareness of the concept and its relation to a topic area.

Courses

Refresher Math (Algebra and Geometry)
Survey of Mathematics (Pre-Calculus)
Applied Calculus I (Differential Calculus) Applied Calculus II (Integral Calculus) Introduction to Modern Mathematics
Selected Topics in Modern Math for the Secondary School Teacher

Comparison of THA-MASTER Calculus and the Traditional Course

The major topic areas of both the differential and integral calculus are taught in detail in the THA-MASTER. Emphasis is given towards student mastery of concepts basic to the calculus -such as the concept of a limit. Even though proofs of some theorems are de-emphasized, the statements and applications of all theorems are stressed, a logical consequence of THA-MASTER, which stresses the training of teachers of mathematics, not research mathematicians. Time is also spent on the mechanics (algebraic techniques) of differentiation and integration since these techniques carry over to topics taught in secondary school mathematics. Topics related to more advanced and specific scientific applications of the calculus (moment and center of mass,,work, fluid pressure,...), specialized techniques of integration (partial fractions, trigonometric substitutions,...) and those geared towards more advanced study of mathematics (hyperbolic functions, polar coordinates and vector calculus) are not covered in detail due to lack of time in the syllabus. Examples of these are the topics of infinite series and differential equations. Throughout THA-MASTER courses "real life" examples from fields such as biology, business, ecology, economics, educational psychology, medicine and the social sciences are given and investigated by the methods of the calculus.

A detailed topic breakdown listing topics covered by a calculus "math major" course and THA-MASTER course at Long Island University is contained in the appendix.

Appendix

Calculus Topics

Topic	Covered in Math Major Course	Covered in THA-MASTER
1) The rate of change of a function	X	X
a) Slopes and equations of a straight line	X	X
b) Functions and graphs	X	X
c) Ways of combining functions	X	X
d) Average rate of change	X	X
2) Limits and Continuity	X	X
a) Theoretical definition of a limit (the "epsilon delta" definition)	X	
b) Theorems about limits	(proven)	(not proven)
c) Limits and infinity	X	X
d) Continuity	X	X
e) Derivative of a function	X	X
3) Derivatives of algebraic functions	X	X
a) Techniques of differentiation	X	X
b) Composite Functions and chain rule	X	
c) Inverse functions	X	
d) Implicit differentiation	X	X
4) Applications of the derivative	X	X
a) Increasing and decreasing functions	X	X
b) Extreme values	X	X
c) The second derivative	X	X
d) Curve sketching	X	X
e) Maxima and minima: theory	X	X
f) Maxima and minima: problems	X	X
g) Rolle's theorem and mean value theorem	X	
h) Tangent line approximations and the differential	X	X
i) Related rate problems	X	X
5) Integration	X	X
a) Antiderivatives - the indefinite integral	X	X
b) Integration by substitution	X	X
c) The area under a curve	X	X
d) Computation of areas as limits	X	X
e) The fundamental theorem of intgral calculus	X	X
f) The trapezoidal rule	X	
6) Methods of integration	X	X
a) Basic formulas	X	X
b) Integration by parts	X	X
c) Integration by partial fractions	X	
d) Special integrals with $\sqrt{a^2-u^2}$, $\sqrt{a^2+u^2}$, etc.	X	
e) Integrals with aX^2+bX+c	X	
f) Trigonometric integrals (and derivatives)	X	X
g) Trigonometric substitutions	X	
h) Improper integrals	X	X
7) Applications of the definite integral	X	X
a) Area between two curves	X	X

Topics	Covered in Math major course	Covered in THA-MASTER
b) Volumes of solid of revolution	X	X
c) Length of a plane curve	X	
d) Area of a surface of revolution	X	
e) Average value of a function	X	X
f) Moments and center of mass	X	
g) Hydrostatic pressure	X	
h) Work	X	
8) Transcendental functions	X	X
a) Trigonometric functions	X	X
b) Inverse trigonometric functions	X	X
c) The natural logarithm	X	X
d) Derivative of Ln X	X	X
e) Properties and graph of Ln X	X	X
f) The exponential functions e^X	X	X
g) Derivative and integrals of exponential functions	X	X
h) Applications of the exponential functions		X
9) Functions of several variable	X	X
a) Partial derivatives	X	X
b) Extreme values	X	X
c) The directional derivative	X	
10) Multiple Integrals	X	
a) Double and triple integrals	X	
b) Cylindrical coordinates	X	
c) Spherical coordinates	X	
d) Surface area	X	
11) Hyperbolic Functions	X	
a) Definitions and identities	X	
b) Derivatives and integrals	X	
12) Polar Coordinates	X	
a) Polar coordinate system	X	
b) Polar equations of conics and other curves	X	
13) Vectors and parametric equations	X	
a) Parametric equations in kinematics	X	
b) Space coordinates	X	
c) Vector components	X	
d) Vectors in space	X	
e) Scalar and vector products	X	
f) Vector functions and derivatives	X	
g) Vector analysis	X	
h) Surface and line integrals	X	
14) Infinite Series	X	
a) Covergent and divergent series tests	X	
b) Power series expansion of functions	X	
c) Taylor and McClavria series	X	
d) Alternating series	X	
15) Differential Equations	X	X
a) First-order equations with variable separable	X	X
b) First order homogeneous equations	X	
c) Special types of second-order equations	X	

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Dr. Long received her B.A. from Queens College, M.S. from Harvard University and Ed.D. from Columbia University. She headed the Division of Education at Long Island University's Brooklyn Campus for fifteen years, a position she left to accept directorship of the Mathematics and Science Institute in 1983. Dr. Long has regularly presented papers at meetings of the National Council of Teachers of Mathematics and the National Science Teachers Association as well as at organizations like the American Chemical Society, the American Education Research Association, the American Association of Higher Education, the Association of Teacher Educators and the American Association of Colleges of Teacher Education. She is on the editorial board of the Journal of College Science Teaching, a member of the New York State Advisory Council for Excellence and Equity for Women and Minorities in Mathematics and Science and has served as a consultant to universities, school districts and state boards for mathematics and science. Her publications range from literature to philosophy, to teacher education, to mathematics and science education.

Sheldon E. Pasner has been an Adjunct Associate Professor of Mathematics at the Institute for the Advancement of Mathematics and Science for the past five years. In this capacity he has taught Refresher Mathematics and has been a workshop leader and instructor in other courses in THA-MASTER. He has also taught a wide variety of computer courses at Long Island University for elementary and secondary school teachers, supervisors and administrators. He has been a teacher of mathematics and computer science at Brooklyn Technical High School since 1961 and has served as Assistant Chairman with the responsibility of supervising twelve classes in an experimental mathematics and computer science program. In his capacity as Curriculum Coordinator for the Comprehensive Mathematics and Science Program at Cooper Union School of Engineering, he has gained considerable experience in the writing and preparation of curriculum materials for all grade levels.

WOMEN IN MATHEMATICS: SUCCESS IN RETRAINING

BY

ROSE MARIE SMITH

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Texas is in severe economic trouble. Texas is exporting population for the first time in the 150-year history of the state. Texas does not play the role of poor with grace. We began our project as a site for the THA-MASTER Program, before disaster hit, in the summer of 1985.

The first class convened during August with thirteen intense students. I taught the first class because I wanted to become acquainted with these students. They were our first investment in this Project.

One student did not survive. This student did come back in the fall; she tried again and made it. Today she is still working on certification in mathematics. I believe she will be successful.

The other twelve students made an A or B. They were hooked. They had always had an interest in mathematics and now wanted to teach mathematics. They had never been in a position to learn mathematics. There were two men and eleven women in this first group. They all had certification and were teaching, but none of them was teaching mathematics. Lynetta Cole, who is here with me at this conference, was part of this first group.

During the fall of 1985, we had our second course. These students had never had a course in trigonometry. Or, if they had, it had been so long ago that they did not

remember much of the material. We used the Survey of Mathematics II to learn about trigonometry. There were twenty-two students in this class. There were two men and there were two black women. Three of these four persons dropped the class. One of the men stayed and has completed the program. We have not had success in working with minorities. We have a good record of working with minorities at TWU, but we were not able to capitalize on that here. One of the two black women returned and worked very hard in later coursework to learn mathematics. We worked very hard together, but we did not have success. We have much to learn here if reclaiming adult minority persons into teaching mathematics is to be successful.

The spring of 1986 brought us to the first semester of introductory calculus. The students faced this task with fear and trepidation. They had an excellent teacher. The faculty in the program are eminently qualified to teach mathematics and, equally important, are successful teachers. Two students, both women, dropped. Both came back later and were successful. The other students finished with good understanding and appreciation for the material.

The first session of the summer of 1986 gave these participants the opportunity to try the second semester of introductory calculus. They were quite strong by this time. Their self image was growing. They could view themselves doing mathematics at this level. One of these students was a woman who had had her first baby during the fall semester, had taken the first semester of the calculus during the spring semester and was now rejoining her colleagues in the program. All finished with flying colors. None was lost from this class.

The second half of the first session was spent with Topics in Mathematics. The teacher realized how hard they had worked in the previous course. The students learned the topics here, and spent some time thinking and preparing materials to present these topics to their future students.

The first part of the second summer session, the students continued on to the History of Mathematics. Again, they were successful. The second course was in Modern Geometry. I taught this course because I wanted to teach in the program. Also, I am very partial to Geometry. By the end of the course, my students shared my love of the subject. They will be good geometry teachers.
The grant was concluded. The students needed one more course to complete certification. Statistical Methods was offered during the fall of 1986 on Thursday evenings. They are enrolled now, and will complete this course in December, 1986.

Some of them will be continuing to work on a Master's degree in mathematics. They will need to take a course in linear algebra to complete the prerequisites for the Master of Science degree in Science Education. Some of them may choose to do some more advanced work in mathematics, so they can complete a Master of Science degree. For some, the work will come now; for others, later, but the door is open. Twenty-three students were helped with this project.

The Department of Mathematics, Computer Science and Physics at Texas Woman's University has a long history of developing mathematics teachers. I was a product of the National Science Foundation Institutes for public school mathematics teachers and then later, an NSF program for college mathematics teachers, both of which were conducted during the sixties. Dr. Harlan Miller, then chairwoman of the Department of mathematics at TWU, was the director of the Institutes at TWU. The impact of these experiences on my life and career cannot be measured. I can identify with each of the twenty-three students who worked in our project.

Dr. Miller received her Ph.D in Mathematics in 1942 from the University of Texas as a student of R. L. Moore. She came to North Texas State University as a member of the Mathematics faculty. She was told that she might not be able to keep her job when the men came home after the war. So, she left North Texas and came to TWU. She served as a faculty member and as chairwoman of the Department of mathematics at TWU until 1968 when she retired. She was capable of doing research in Mathematics, but teaching was the love of her life. Some of the faculty who worked with her taught in our project. She has left an important legacy for today.

We have just completed another grant at TWU in which we were able to give stipends to the involved students. This is the first time we have been able to do this since the NSF Institutes disappeared in the early seventies. This kind of monetary support is important if we are to reclaim competent people as teachers of mathematics. The resources for the reclaiming project are women who will do the coursework necessary to learn mathematics on a part-time basis. These women are a resource available to us but we must proceed with caution. They have been told all of their lives that, as women, they are unable to join, and unwelcome for inclusion into the world of mathematics. They must hear another message and that message must be loud and clear.

In an article entitled "Working Mothers Raise Better Students" in the Denton-Record Chronicle for August 26, 1986, four researchers from Ohio, who presented their findings to the American Psychological Association in Washington, reported the following:

o Children of working mothers tend to do better in school, are absent for fewer days and have better communications skills, than children whose mothers are in the home during the day;

o Women who have jobs outside the homes are more likely to be confident they are good mothers, and their children report better relationships with them;

o Overall, the child benefits when the mother works;

o All significant differences in social and academic criteria favored children of employed mothers;

o The "traditional" American family -- with the father as sole breadwinner and the mother a full-time homemaker--is becoming a rarity. By the year 1990, only 14 percent of the households in America will live in this family pattern.

This kind of hard research data is showing the increase in the skills of parenting of the working woman. Certainly the improving parenting skills of the husband of the working woman is also noted here. Notice the men taking young children to childcare centers these days. Notice the women and men in the grocery store in the evening with small children in tow. Something is changing in this country. But people in the world of mathematics are not keeping in touch. I could cite three examples.

My first story concerns a meeting I attended about two weeks ago. We had been working together for about a year-and-a-half. Normally, there were representatives from industry with us, but this was a subcommittee on computer science curriculum. All academic types. Usually, there were junior college representatives; today, there was only one junior college representative, and he came late.

Normally, for computer science curriculum discussions, the representatives would reflect an engineering background, a mathematics and science background, or a business background. On this day, however, the fifteen people all came from an engineering background.

Thus, the people in the room when I arrived were administrators from engineering. One was an associate dean, instrumental in the development and building of a Robotics Institute which has impressive economic backing from industry in the metroplex area. This dean had been able to cause an influential group of women, based in Austin but with contacts throughout the state, to consider ways in which girls can be encouraged to study mathematics and science. The idea has spread in the group and has received good support and committment. There seems to be an understanding of the difficulty of the task. These are

women who, for the most part, have successfully avoided mathematics and science in their own lives, but they realized the growing importance of mathematics and science in the lives of our next several generations, and are creatively developing strategy to proceed.

As I walked into the room with my fifteen male colleagues, I said hello to most of them, for we knew each other. I introduced myself to the few new faces. Two of the men had received promotions since last we met. A "Hail, fellows" attitude prevails. The boys and I arranged ourselves around the table. We had each brought a large set of materials with us. We had a bureaucratic task in front of us. Our entire assignment was an outgrowth of the Mayor's Task Force on Technology. The Fort Worth-Dallas area is desparately grasping to become successful in the technology marketplace. Certainly, the potential exists in this exciting part of America.

As we settled into our work, one of my friends comments that there was only one restroom for women in this building. We normally had met in the student union building, but today we were in a seminar room in the engineering building. He continued to say that the secretaries needed a ladies' room and he had helped them draft a manifesto to secure one. The request had been granted. The result was that a new sign had been hung on the door of one of the restrooms down the hall. He laughed, and further commented that no plumbing changes had been ordered. He announced, with glee, "the urinals remained!"

As he made these absurd statements, the other men began joining in the ridiculous comments. I could only stare at my colleagues with disbelief. The leader's final parting shot was: "If women are going to come into engineering, they will just have to realize that this is a man's world."

Shortly, the foolishness concluded. We then proceeded to our tasks and spent a productive two hours engaging one another in interesting and challenging conversation concerning the first two years of study in an undergraduate degree in computer science. The role of mathematics in the study of computer science was discussed.

As we broke for lunch, I asked, "Can one of you show me where the restroom is?" They all laughed!

This is not a funny story. The men in this story were open with their uncomfortableness at my presence. The woman in the engineering setting causes turmoil. The great white male is threatened. We must deal with this if we want women and minorities in mathematics. Scenarios such as I have described are playing out all over the country with very young women, and with women older than me.

My second example is about a student I passed in the hall. "Do you know who is teaching Elementary Analysis I in the spring," she asked with a desparate look on her face. I heard her question before I noticed her. As I looked at her, I recalled why I knew her. She had come to my office to complain about one of our graduate teaching assistants who is her teacher this semester. We had talked a long time. "You know my needs," she continued. I recognized the plea on her face. "I'm not sure yet of class assignments for Spring," I quickly replied. "Let's talk again closer to registration. I'll help you find a good situation," I promised. Her face relaxed a little and she walked away. I filed her name and face away in my mind so I would remember to help her. She wants to learn some mathematics, but she has little background. She deserves a chance. She carries a heavy burden. She represents many women. I will help her, but can she hang on to learn the material she has been denied?

My last story concerns a woman who was sitting in a chair outside my office door. A Hispanic woman about forty-five years old. She was in extreme distress. She was taking a computer literacy class. She is currently working on a degree in elementary education. Her teacher was a woman from India with a Ph.D in Computer Science. Olivia told me of her distress. Her voice rose as she came very close to tears. She felt her grades were very poor and was afraid she would fail. She did not need this threat. Going to college was important to her and her continuance and eventual success was important for many reasons. She has had very little experience with quantifying situations. She had to feel that I understood her distress before we could begin to discuss her problem. Two days later, there was a note in my box: "Thanks for listening to my woes."

Would my engineer-colleagues have understood the needs of this middle-aged Hispanic woman? Could they, or would they, have helped? My guess is NO. They believe that the student who needs care is capable only of second-rate curriculum. They don't understand that needing support to succeed is not being weak. They haven't been to the well. The human resources are all around us, but the stage must be properly set. Dr. Harlan Miller, my mentor, understood this. She expected more from me than I knew I had to give. I produced for her in a way that was impossible to do without her. We never discussed this, but she knew and I knew. I would have quit many a time, except for her. I owe her. My debt to her can only be paid by reinvesting.

In the report of the National Science Board Task Committee on Undergraduate Science and Engineering Education, March 1986, the following comments appear:

"The Nation is not being adequately served by current efforts to increase the number of women and minorities in the science and engineering workforce. Unless these efforts are maintained where they are effective and intensified where they are not, the nation will continue to deprive itself of an important source of future scientists and engineers to offset the decline in total number of new entrants expected between now and 1995."

There is a glimmer of hope in this statement. Clearly, some efforts are successful. Will the National Science Board be perceptive enough to seek out these abilities? I hope so.

There are other signposts: On the cover of Electronic Learning for Sept. 1986, there were pictures of four executives from IBM, Tandy, Commodore and Apple Corporations. In the accompanying article, these four are described as "complex, clear-thinking, tough, savage."

Betsy Pace, 32, is the manager for K-12 educational Marketing for Apple. She is further described as intelligent, clear-thinking, realistic, sincere, and thorough reflecting the youth-oriented, serious, analytical approach of the new wave of Apple executives. Except for "sincere" you might not notice Pace's first name is Betsy.

An article in The Chronicle of Higher Education, August 6, 1986, comments that the appearance of the David Report has helped persuade Congress to provide the field of mathematics with relatively impressive increases in support, which have exceeded 10 percent annually since fiscal 1984.

The panel recommended that mathematicians "greatly step" up efforts to increase public awareness of fundamental mathematics and its importance. Kenneth Hoffman, professor of mathematics at the Massachusetts Institute of Technology, served as executive director of the David panel and has started a project to increase public awareness by making mathematicians more available to the press.

He urges that Mathematicians publicize meetings, promote greater coverage of mathematics by the news media and suggests that mathematicians at universities spend time educating the public about mathematics.

Hoffman states that we have just entered an era in mathematics that is going to defy anything the world has ever seen. That, coupled with the computer revolution, is going to make the next 20 years something to see. It is important that this society be ready to participate.

I would submit that the role of women and minorities in mathematics and science can, similarly, be publicized with

huge payoffs for our nation. Women have left the classroom but they are returning. They will be needed and minorities will be needed if this country is to participate, much less take a leadership role, in this important development.

In Lynn Steen's compelling article in the College Board Review for the summer of 1986 entitled "Stress Points in School and College Mathematics," he mentioned that the first point of stress was the sad fact that most of the mathematics taught in United States colleges and universities was really high school mathematics. His second comment was on the need to add newly-important parts of mathematics to an already over-filled curriculum. This second stress point came mainly from the public to add courses in computing.

Another stress point raised: "Should we continue to teach students to carry out by paper and pencil the many calculations that computers can now do much better?" Steen discussed what he calls three curricular gyroscopes: teachers, textbooks and tests. He spoke of a particular, and serious stress imposed by each of these. His outcome is exciting and appropriate:

> We must find a better way to educate students who leave mathematics at an early stage of the curriculum, although not at an early age.
>
> They need to be taught in a way that will build confidence in their own abilities to ask the right questions and to be skeptical of disingenuous answers.

I would submit that another subtle but powerful point of stress has been the evaporation of women as a steady source of good mathematics teachers for our public schools.

Women have left the classroom, but they are returning. They must have incentives to stay.

In the conclusion of his article, Steen spoke of the establishment of the Mathematics Science Education Board. Shirly Hill of the University of Missouri at Kansas City will chair the MSEB which will be charged to provide a continuing national capability for overview and assessment of mathematical sciences education.

Professor Shirley Hill represents a woman respected by the science community. Her prestigious position on this board recognized publicly the importance of women in the solving of the national problems related to mathematics education.

The mathematics curriculum is in disarray in Texas. Coupled with the severe economic problems facing the state the stress on Texas public school teachers is extreme. We need a model public school mathematics curriculum in Texas. We have well-meaning mathematics teachers teaching Informal Geometry and Computer Mathematics on the one hand, while on the other hand staff members of the Texas Education Agency are unable to tell these teachers if the specific course content they are teaching during any given week is appropriate.

We must retain the women and men we have in the mathematics classrooms today. We must send the message to them that they are needed, that they can receive the help they need to do a better job with each group of students they teach.

We must formulate a curriculum that will prepare the college-bound student and the student who goes into the marketplace.

The "Program to Prepare Teachers of Mathematics" at TWU and the other sites around the country was a good beginning. Twenty-three mathematics teachers received this kind of support with a $15,100 investment from FIPSE, leadership support from Dr. Long, in-kind contributions from TWU, and exciting classroom interaction with competent faculty and dedicated students.

This was a project we were proud to be a part of and have high hopes that other related opportunities will be available.

A native of Beaumont, Texas, Dr. Rose Marie Smith completed a B.S. in Music at Lamar University, an M.A. in Mathematics at the Texas Woman's University, and an Ed.D. in Higher Education with Mathematics Specilization at Oklahoma State University.

She has been on the mathematics faculty at T.W.U. since 1967 and is currently serving as the Chairwoman of the Department of Mathematics, Computer Science and Physics. She has directed the Honors Program and served as Associate Vice President for Academic Affairs previously at T.W.U.

She was the site director for "A Program to Prepare Teachers of Mathematics" at T.W.U. from 1985-86.

A STRATEGY FOR RETRAINING OF TEACHERS FOR PHYSICAL SCIENCE

BY

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&

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INTRODUCTION

Concern over the shortage of science teachers, especially those in physical sciences, has been expressed in many forums. Various recruitment techniques to fill thin ranks have been proposed. Long term solutions have addressed ways to enhance the desirability of science teaching as a career to be considered by today's youth. Short term solutions have addressed ways to attract current professionals into the science classroom.

Two divergent methods have been suggested to recruit these professionals. One method is to attract individuals with science/engineering backgrounds to step into the classroom. Some proposals have involved temporary, visiting assignments by scientist/engineers to aid current teachers, or teach part-time in critical courses such as physics or calculus. Other proposals have aimed at recruiting scientists/engineers who are retired or near-retirement to consider a "second-career" as a science teacher. However, these proposals face the problem of re-training these professionals to have adequate knowledge and skills for the educational environment in the secondary science classroom.

The second method has looked at retraining current teachers from other disciplines into teaching in the sciences. The criticism of this method has been based on the assumption that retraining these teachers to gain adequate knowledge of the content and skills of physical science would be very difficult and that they would not develop an enthusiasm and love for the discipline because of their own "anxieties" about learning physics. However, these teachers have experience and the prerequisite training in teaching in the education environment at the secondary level.

PROGRAM PHILOSOPHY

This paper presents a strategy that attempts to overcome the criticisms of second method and successfully retrain teachers from other disciplines to be able to teach physics and physical sciences in the secondary classroom. To do this, a philosophy was adopted that the process of teaching the content and problem solving skills exemplified in physics to these teachers should be a model for them to use in teaching, i.e. to teach as they were taught. Recognizing their potential anxieties and "fear of physics", this model had to address ways to overcome pre-existing misconceptions and alleviate anxiety while bringing comprehension of physical science to an adequate level for them to step into the classroom with confidence and enthusiasm. Master high school physics teachers were included on the staff to provide effective teaching models for the high school classroom. The physics content covered the traditional subdisciplines. However, processes for analysing information and gaining insight into a content area were emphasized, so that these teachers would feel confident at moving into new areas on their own, rather than teach "rote information" from a text. In addition, the courses were to be offered over a fifteen month period, allowing participants to continue in full time employment while completing 20-23 credits (quarters).

NEEDS ASSESSMENT

Need for this program was assessed in a step-wise process. Initially a survey questionaire was sent to the administrators at 220 senior high and 185 junior high schools through out Colorado. Approximately 11% (43) of the forms were returned. These 43 respondents estimated that in their districts approximately 25 teachers were assigned to teach physics or physical science with less than one-year of college physics preparation, and approximately 60 teachers would benefit from participation in this program. Incentives or rewards for a teacher to participate in the program identified by these administrators were: salary increments (40%), job security (33%) recognition (9%), self-satisfaction and better understanding of physics (9%).

These administrators indicated that 33% of the districts would be willing to aid in retraining through stipends, released time, etc. and estimated that approximately 43 teachers would be willing to participate and provided 40 names of potential participants.

For logistic reasons, the first offering of this program was focussed on the high-population density Front-range area centered around Denver. The next step in assessing needs was to send brochures to all names suggested by respondents to the survey, to all school districts in the Front-range, to names on mailing lists of science teachers in the Denver area, and to individuals requesting information about the program. From these brochures, we received 77 requests for application materials (31 female, 46 male). We screened the applications to determine the number who had the required minimum math and science backgrounds, but who did not have extensive preparation in physics. Twenty-eight participants (11 female, 17 male) were accepted into the program.

PARTICIPANT PROFILES

The background of the participants was varied, though dominated by 15 individuals having majored in Biology. Other undergraduate majors represented were: 1 home economics, 1 physical education, 1 industrial arts, 1 physical geography, 1 earth science, 2 mathematics, 2 science education, 2 chemistry, and 2 physical science. The 4 in physical science and chemistry petitioned to be included even though they had previous preparation in physics. All four had received their degrees over twenty-years ago and desired a "refresher". The other 25 participants averaged 5 semester credits in physics preparation, compared to an average of 28 semester credits in biology, 13 semester credits in chemistry, and 11 semester credits in earth science. Fourteen of the participants had math preparation through at least introductory calculus, 11 others had at least college algebra, and 3 technical or general introductory math.

This data collectively demonstrated the need for a retraining program. In particular, there seems to be a cadre of biological science teachers interested in moving into physical science teaching.

CURRICULUM

The first course in the program is a preparatory course. This course reviews some basic algebra and trigonometric manipulation, then emphasizes quantitative problem solving through graphical analysis, making estimations and model

calculations ("Fermi problems"), and utilizing verbalization and feedback (e.g. see Clements & Lockhead). This course is delivered as a two-week intensive workshop during the summer.

The sequence of four content courses are offered over 12 months in a format of 12 repeating three week patterns consisting of a Thursday evening during week 1, an intensive all-day Saturday at the end of week 2, and a Thursday evening during week 3. A week of individual study typically separated each 3 week cycle. The Saturday classes incorporate laboratory activities extensively.

The nominal content is structured around the typical sequence of Mechanics; Light, Heat and Sound; Electricity and Magnetism; and Modern Physics. The high school master physics teachers are used to help structure the course so that the college level physics learned by the students can be applied to teaching activities encountered in the high school classroom.

The final course is a seminar in "Current Problems in Teaching Physics". This course reviews the recent literature as it relates to perception difficulties students have with physical phenomena, the concepts of cognitive science applied to physics instruction, and the discussions of the role of physics within the secondary school curriculum.

EVALUATION

The key to this strategy hinges upon establishing that the participants gain an understanding of the content and have a feeling of confidence and enthusiasm for teaching physics.

To demonstrate the comprehension of content, a pre-test and post-test were used. These were multiple-choice tests that covered the topics of the four content courses. The questions used for the pre- and post-test have been standarized nationally for students completing one-year of college-level physics.

The pre-test scores for the 28 participants averaged below the 20th percentile of students completing one-year of physics. One individual showed a pre-test comprehension equivalent at the 75th percentile level and six others were grouped in the 40 to 75 percentile region. The remaining 21 were below the 30th percentile.

Of the 28 participants that started, 14 (50%) completed the program. Those 14 that completed the course had a pre-test average at approximately the 20th percentile, while the other 14 had an average at about the 12th percentile. The post-test scores of those that completed the course showed improvements with one above the 90th percentile and two others above the 75th percentile. Five were in the 30-75 percentile and three remained below the 20th percentile.

The non-finishers were 9 Biology, 1 Math, 1 Home Economics, and 1 Science Education major. The finishers typically had 8 semester hourse more physics preparation than did the non-finishers, and the math preparation was similar.

The enthusiasm and confidence level were measured by a self-evaluation done by the participants in response to a questionaire upon completion of the program.

There were also standard course-evaluations completed by the students at the completion of each course. These evaluations provided feed-back about the students perceptions of the appropriateness of the courses and the extent to which the program was meeting their goals.

COMMENTS

This program has been successful in this format in the populated metropolitan area. However, a severe need for this type of retraining exists in Colorado and many other western states in the rural school districts. Typically, the science teachers in these rural districts must cover two to four content areas (e.g. some rural districts have one science teacher for all science, grades 7-12.) In addition, these teachers typically receive lower salaries (by differentials as large as 50% of metro salaries). These rural districts typically have a single high school serving a geographical area greater than 350 square miles and a student population less than 50 per grade level. Therefore, a program cannot draw an adequate number (15-20) of teachers to a central location (commute distance less than 50 miles) to participate. Possible modifications of this program would be to offer a summer program on campus. However, this model would require funding for subsidizing the relocation and housing costs of these low paid teachers to move 100-400 miles each summer and then return. Another possible model would be to utilize telecommunications, computer assisted learning, and pre recorded video materials. However, this model would also require substantial funding and creative adaptation to still incorporate the "teach as you were taught" and hands-on laboratory experiences. This model does offer the potential for the most radical innovations to occur, and perhaps provide beneficial models for exploitation of these technologies for other educational settings.

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Dr. Paul Lightsey was Site Director for the THA-MASTER Program in Physics at the University of Northern Colorado. Dr. Lightsey was chairperson of the Physics Department and also chaired the ad hoc committee that developed the interdisciplinary Masters Degree in Science Teaching at UNC. Dr. Lightsey received his B.S. at Colorado State University and his M.S. and Ph.D. at Cornell University. He has been active in science teacher preparation and in professional education organizations including the Society of College Science Teaching/National Science Teachers Association and the American Association of Physics Teachers (AAPT). He has served on national committees and as a section officer in the AAPT. In addition, he is a member of the Optical Society of America, Society of Photoinstrumentation Engineers, American Institute of Aeronautics and Astronautics, and Sigma Xi. Dr. Lightsey is currently employed at Ball Aerospace Systems Division. He remains active in education concerns serving on the Steering Committee of the Colorado Alliance for Science and continuing as an Adjunct Professor at UNC.

Wallace Aas received his B.S. at Morehead State Teachers College and his M.A. at the University of Nothern Colorado. He has chaired the Physics Department at UNC from 1966 - 1981. Professor Aas is keenly interested in researching applications of learning theories to science teaching.

RETRAINING EINSTEINS

BY

WALTER GLICKMAN

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Albert Einstein was a high school dropout. What he hated most was the authoritarian atmosphere and the emphasis on rote learning he experienced at the gymnasium (high school) he attended in Munich. The only schooling he ever enjoyed was the year he spent at a Pestalazzi oriented school in Switzerland, where he found freedom and kindness and was encouraged to ask questions. When he enrolled at the Zurich Polytechnical Institute the following year, his intention was to be trained as a high school physics teacher. Things turned out otherwise. Theoretical physics became his life work, but his concern for education never slackened. He has been a guiding spirit on our efforts to retrain high school physics teachers at Long Island University's Brooklyn Campus.

The aim of science, for Einstein, was to coordinate experience and bring it into a logical system. In this he agreed with other eminent scientists of our age. Physics seeks to expose patterns compatible with our sense impressions of the physical world. Now in order to teach young people and their teachers this knack it is important to be aware of several factors that seldom work their way into curricular discussions.

Consider the role of imagery. Image is the root of imagination. Einstein thought in images:

> The psychical entities which seem to serve as elements in thought are certain muscular signs and more or less clear images which can be voluntarily reproduced and combined. ...this combinatory play seems to be the essential feature in productive thought before there is any logical construction in words. ...Imagination is more important than knowledge.

Imagery and imagination can be of great practical value. For example, I am bothered by the term "retraining" because I picture a train being switched from one track to another, a one track mind being re-routed. Playing with these images suggests: de-railing dogmatic thinking, opening vistas by getting people off the trains, having them walk, or fly. Re-trained teachers are sometimes referred to as retreads -an apt image. That suggests a solution. Let's not present physics as a separate veneer but as an outgrowth of history and of human activity, creating a strong bond, a glue that connects the new to the known.

The role of analogy and metaphor is a powerful one because it encourages the innate ability of our students to see patterns; to look at a set of data or observations and

exclaim " I see it!" Imagery, imagination, intuition are effective in grasping the gestalt, in seeing how the details hang together; that is what is meant by "getting the hang of it".

The ability to see the entire pattern as a whole is therefore vital in scientific understanding and in effective science teaching. But this ability can not be transferred by memorizing definitions or equations, by sets of rules or ordering of topics. "There is no logical path to these laws [of nature];" says Einstein, "only intuition resting on sympathetic understanding of experience can reach them." Sympathy and intuition are feelings. Analysis alone is fruitless. As we teach our students to dissect and separate nature into its smallest parts, we must teach them as well to feel the harmony of the whole. It's a basic skill. Einstein spoke of it in these words:

> The individual feels the sublimity and marvelous order which reveal themselves in nature and in the world of thought... He wants to experience the universe as a single significant whole... In my view it is the most important function of art and science to awaken this feeling and keep it alive in those who are capable of it.

How do we awaken this feeling? How do we reveal the simple in the complex, the order in the apparent chaos of our experience? By cultivating the innate sense of wonder and beauty that lurks in all of us. "All our detailed knowledge", said Einstein, "is but a flight from wonder." "The scientist does not study nature because it is useful", said Henri Poincare, "he studies it because he delights in it, and he delights in it because it is beautiful." "There exists a passion for comprehension, just as there exists a passion for music." said Einstein, "That passion is rather common in children but gets lost in most people later on." The essence of physics teaching lies in the ability to preserve or restore that passion.

To teach science, teachers must be more than trainers, they must be educators in the root sense of that word, drawing forth the innate ability to wonder, to question, and to respond to the harmony of nature. We are not selling detergents or breakfast cereals or deodorants whose appeal needs to be jazzed up for its customers. The products we are selling are among the greatest works the human mind has ever created. Like great symphonies or paintings, the patterns physicists have found to correlate with experience are breathtaking.

Of course, no mind has yet come up with "the ultimate pattern", nor is this likely to happen. The discoveries of science are open ended. Educationally, this is good news for two reasons. Students have a stake in the action; the laws of physics are open for re-vision. And teachers can answer

any question with "I don't know" and not feel guilty.

But "I don't know" is not enough. To engage a class in meaningful dialogue a physics teacher must be thoroughly conversant with the basic concepts of physics. Although a strong base in Newtonian mechanics and electromagnetism is essential, one should also be familiar with the atom, the nucleus, and have some knowledge of such subjects as superconductivity, quarks and the big bang theory. The great discoveries of outstanding physicists are valuable learning tools as well. Niels Bohr's theory of the hydrogen atom employs mechanics, electricity and quantum jumps, which can be understood on an elementary level, and the theory exhibits what Einstein descibed as "the highest degree of musicality in physics". A couple of weeks spent on the Theory of Relativity is not a bad idea either.

> Science is our century's art. The takeover can be dated more precisely than the beginning of most eras: Friday, June 30, 1905, will do, when Albert Einstein, a clerk in the Swiss patent office in Bern, submitted thirty-one page paper, "On the Electrodynamics of Moving Bodies", to the journal Annalen der Physik. No poem, no play, no piece of music written since then comes near the theory of relativity in its power, as one strains to hear it, to make the mind tremble with delight. Whereas fifty years ago it was often said that hardly twoscore people understood the theory of relativity, today its essential vision, as Einstein himself said., is within reach of any reasonably bright high school student.
>
> H.F.Judson,
> Search For Solutions

So we want high school physics teachers who are not only well versed in their subject, but are prepared to provide essential visions, stimulate imagination, imbue a sense of wholeness, so their students can hear the music before playing scales and feel what science is, and what scientists feel. To reach adolescents, to hold their attention, to compete successfully with sex, drugs and rock and roll, only something that can "make the mind tremble with delight" has a chance.

Dr. Walter Glickman received his B.S. at Alfred University and his M.S. and Ph.D. at Pennsylvania State University. His research interests led him to studies in the development of techniques that would increase conceptual understanding and the sense of wonder in young people as well as a concern with unifying factors of such diverse disciplines as science, art and religion.

SERVICES PROVIDED BY THA-MASTER

THA-MASTER can provide information and services to all interested parties who wish to become further acquainted with and involved in its unique program. This offer is addressed to rural, urban, suburban and special interest groups wishing to further the educational excellence of their communities. In particular, universities, school districts, private and public elementary and secondary schools and state education departments are invited to communicate with us. Services of interest include:

* technical assistance
* recruitment
* speakers and consultants
* staff development
* evaluation materials
* course descriptions and course design
* video-tapes
* dissemination techniques
* networking
* strategies for dealing with adult learners

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Herbert J. Sacher
Editor
Assistant Professor, Science Education
Long Island University

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APPENDIX V

FINAL SITE REPORTS

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ARIZONA STATE UNIVERSITY

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FINAL REPORT

The Hellman Academy for Mathematics And Science Teacher Education and Retraining

FIPSE Funded

Arizona State University
August 31, 1986

OVERVIEW

The THA-MASTER program at Arizona State University was conducted in close cooperation with neighboring school districts. This close involvement of the school districts in the program over the past 18 months is considered one of the stronger features of the project as implemented in this area.

School districts were alerted to the forthcoming Academy in April, 1985, and were informed of its objectives and availability to certain teachers. Districts were invited to send those teachers whom they considered to be most able to benefit from the program, and whose subsequent service would be of greatest benefit to their districts. The participants consisted of those sent by the districts.

The program began with thirty-two participants, and ended with 19. The pre-test was given early in the program, and the post-test on the next to the last day of meetings with the participants. On a comparison of the performance of the participants on the two, there was a marked increase in their level of performance, with a difference between the two tests at the 0.01 level of significance.

All participants who completed the program but three are being utilized by the districts as full time mathematics teachers. Some are so elated with their

new assignments they have gained renewed interest in teaching and are finding their activities this year exciting and challenging.

EXPECTED RESULTS

One of the expected results of The Hellman Academy for Mathematics and Science Teacher Education and Retraining, aside from the immediate benefit of providing a pool of better prepared teachers in an area of critical shortage, was a demonstration of the feasibility of conducting a program for improving the preparation of mathematics teachers as a cooperative venture between a university and its neighboring school districts.

Teachers sent by their districts as participants were assigned either part-time or full time by their districts as mathematics teachers, and were viewed by their districts as having good potential as mathematics teachers, but were inadequately prepared to teach mathematics.

Programs of this kind usually deal with teachers as individuals, with little communication actually taking place between the program director and the respective districts from whence the teachers come. There were several possible advantages for making initial contact and handling all publicity entirely through the district administration and for wanting to involve the districts in the selection of those teachers from their districts who would participate. It would cause the districts to review the mathematical backgrounds of preparation of their respective teachers. It would cause each district to emphasize to their teachers that they were aware of them and their potential as mathematics teachers, and were giving them moral support in their studies. It would provide an opportunity for increased dialogue, in a constructive and meaningful activity, between the districts and the university. It would increase the likelihood the increased abilities of the teachers would be more fully utilized by the

districts upon completion of the program. It would demonstrate the feasibility and the advantage of working only through districts.

The expected result of bringing university and school personnel together in a cooperative venture to achieve a common goal has been fully realized.

There were other expected results from this project. There is a chronic shortage of qualified mathematics teachers in our society. One of the reasons for this shortage of qualified mathematics teachers is the difficulty always experienced in retaining prospective teachers to teach mathematics after they have worked so hard to obtain the knowledge in mathematics that will qualify them to teach. With that knowledge, the lucrative jobs in industry are available to them and, too often, they are drawn away from teaching. By recruiting teachers to be trained in mathematics from the ranks of experienced teachers, it would be demonstrated that this is a prime area for recruitment of potential teachers of mathematics. In addition, by recruiting from this group, it could be demonstrated the cost of preparing a teacher of mathematics would be much less than for recruiting and preparing an entering college freshman.

A total of nineteen teachers completed the final phase of the program (see Attachment A). Sixteen of those completing the program have been assigned to teach mathematics full time in the fall by their respective districts. The districts of the remaining three have been notified of the preparation of these three and have been alerted to the practicality of their being assigned to teach mathematics full time. It should also be mentioned that six of those teachers who dropped out, and did not complete the entire program, have obtained, through the program, better backgrounds than some of those teachers available otherwise to teach mathematics in their respective districts. These "dropouts" have also been assigned by their districts to teach mathematics full time.

The expected result of demonstrating the feasibility of recruiting teachers from the pool of experienced teachers to prepare and qualify to shore up areas of shortage and need has been fully realized .

FINANCIAL STATUS

Because of the level of interest of the school districts, Arizona State University agreed to allow all participants in this program, throughout its duration, to register for college credit without charge. When it was more convenient to the participating teachers to meet at one of the schools in the area, rather than on the campus at Arizona State University, districts opened their facilities to our use at no charge. This would occasionally include not only the use of rooms for meetings, but the use of overhead and projector equipment as well. The Department of Mathematics at Arizona State University absorbed all the expenses for secretarial work, duplicating, mailing, etc.

This has been a case of everyone being willing to contribute resources to the project. The actual funding through FIPSE has really been seed money in view of the total costs and expenditures. This willing cooperation is one of the measures of the success of the program. It has brought a wide range of people together in pursuit of a common goal needing the emphasis this program gave.

FOLLOW-UP

In Arizona schools, students are tested on standardized tests at the end of each school year. On the basis of these tests, districts will be asked to make a comparison of the students of those teachers who participated in this program with the average for the students of these same teachers in years past, a comparison of the performance of the students of these teachers with the average for the students in the entire district in the past, and a comparison of the

students of these teachers with the average for the students in the entire district in the same year. If districts are not interested in making these comparisons, they will be asked to make the data available to Arizona State University so the comparisons can be made.

The success of the students in the classrooms of our teachers is the ultimate measure of success of our programs of preparation for those teachers.

SUMMARY

There are many valuable lessons that have been learned from this activity which should be reviewed and remembered and should serve as a guide in future programs. Some of these lessons were looked for, and others have been learned through chance.

Any program of this kind is fully successful only to the extent that school administrative personnel are meaningfully involved. Through their involvement, school personnel have become more aware of the need to upgrade their teaching faculties. There is a greater and more accurate awareness of certification requirements. Higher standards are being set by some districts.

A close working relation can be established and maintained between university personnel and school personnel that results in stronger programs and greater benefits to all. Many teachers are ready and willing to study hard over an extended period of time in a systematic and organized program set up to meet their specific needs.

One of the most profound lessons learned is that the pool of experienced teachers is a prime area for recruitment of additional teachers of mathematics.

There have been noteworthy benefits resulting from this program that were not anticipated at the outset. The improvement of teachers and teaching is now seen by this university and its neighboring schools more as a cooperative effort rather than the sole responsibility of either. This program has put in place activities, and has broadened horizons, that will continue to bear fruit for years.

It would be a mistake to say that any one benefit from this program was any more important than another. However, it would be reasonable to suggest that a strong contender for that designation would be the benefit given directly and indirectly to the people involved. This program has breathed new life into mathematics education at Arizona State University and the surrounding communities at a time when it was sorely needed, and has given encouragement in an area where new activity, life, and enthusiasm is a benefit to all. To say that this came at an opportune time would be an understatement. This one thing alone is adequate justification for having run the program. We will all benefit from all the lessons learned and the directions set. But because of the changes in attitudes of individuals, and the encouragement and renewed commitment of individuals, only time will be an adequate measure of the full benefits accruing from this program.

June 27, 1986

Dear Dr. Long:

Thank you so much for the opportunity to participate in THA-MASTER. The classes have been interesting as well as informative and have allowed me to complete the mathematics credits required for teaching math in Arizona high schools. Math is a new field for me and by completing this program I feel confident that I will be a better teacher. I have secured a high school math teaching position for the 1986-87 school year and am looking forward to getting started in the classroom.

Thank you again and please know that your efforts are greatly appreciated.

Sincerely,

Mary Frishman

Mary Frishman

July 1, 1986

Dr. Madeleine J. Long, Director
THA-MASTER
Long Island University
The Brooklyn Center
Brooklyn, N. Y. 11201

Dear Dr. Long,

As the THA-MASTER course work concludes at Arizona State University, I would like to thank you for your efforts in providing this necessary and timely program.

With Bachelors and Masters degrees, plus six years experience teaching at the elementary level, I decided I much preferred teaching Mathematics to junior high students. As an undergraduate, I had a number of Math courses. Yet I lacked the proper courses to receive State certification at the secondary level. THA-MASTER has given me the wonderful opportunity to complete a secondary certificate while satisfying my district's requirements for graduate work.

The THA-MASTER program at ASU has offered appropriate courses taught by master instructors. It has been a year wherein I have grown a great deal. The students I teach will be the ultimate beneficiaries. Thanks again for all your endeavors. I am truly grateful for the opportunity.

Sincerely,
Marilyn Wilcox
Marilyn Wilcox

July 3, 1986

Dr. Madeleine J. Long, Director
THA MASTER
Long Island University
Brooklyn Center
Brooklyn NY 11201

Dear Dr. Long:

My students and I wish to express our appreciation for my unique opportunity to participate in the THA MASTER PROGRAM. My exposure to mathematics has been substantially increased during this past year. The high caliber of professional educators serving as our instructors has been a definite asset to the program. This inexpensive professional growth has advanced my career and the quality of my work. I thank you and Dr. Lehi Smith for this "chance to learn".

Sincerely,

Nancy Hickey

Nancy Hickey

2330 N 87th Way
Scottsdale, AZ, 85257

Dr. Madeleine J. Long, Director
THA-MASTER
Long Island University
The Brooklyn Center
Brooklyn, NY, 11201

Dear Dr. Long,

I have been involved in the program of obtaining additional credits and course work in the program here at ASU. The efforts of Dr. Smith and other professors has greatly increased my knowledge of mathamatics and will in turn better my teaching methods and work with children. I wish to express my appreciation for the time and effort that you expended in establishing and funding this program. Not only have we worked hard in the program but we have established a close group. The other day a fellow classmate suggested we have a prom since it is near graduation.

Sincerely,

Stanley Dunn

3134 E. McKellips #181
Mesa, Arizona 85203
June 30, 1986

Dr. Madeleine J. Long, Director
THA-MASTER
Long Island University
The Brooklyn Center
Brooklyn, New York 11201

Dear Dr. Long,

As an Arizona State University student involved in the THA-MASTER program, I wish to thank you for your efforts to bring the program to Arizona. It has been of value in my teaching and will allow me to be certified as a secondary math teacher. This is very important to me. I hope the program can continue so as to allow more teachers to have this wonderful opportunity. We've needed this program for a long time.

Several teachers in my district had been trying to get our district to offer a program like this. We were not making much progress, but were going to continue to be persistent. Then A.S.U. notified our district of this program; it was and is exactly what we nad been working for. Thank you for being instrumental in getting this much needed program to Arizona.

Sincerely,

Yvonne Dupont

(Mrs.) Yvonne Dupont

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BEAVER COLLEGE

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SITES OFFERING THE THA-MASTER

Information regarding these sites can be obtained by contacting:

Madeleine J. Long, Ed.D.
Project Director, Model Site
THA-MASTER Program, Rm. M-602
LIU/Brooklyn Center
University Plaza
Brooklyn, New York 11201
Telephone: (212) 403-1056/1011

A. Richard Polis, Ed.D.
Site Project Director
THA-MASTER Program
Beaver College
Office of Graduate Studies
Glenside, PA 19038
(215) 572-2960

THA-MASTER
The University of Miami
School of Education and
the allied Health Sciences
Miami, Florida 33124
Telephone: (305) 284-4301

THA-MASTER
College of Education
The University of Kentucky
Lexington, Kentucky 40500
Telephone: (606) 257-2944

Please send application and additional information on:

_____ Beaver College Master of Arts in Education Program

_____ Certification in Mathematics

For an appointment please call: (215) 572-2959

Please print

Name _____

Address _____

City _____ State ____ Zip _____

Telephone _____
Home Business

Beaver College
Graduate Studies Office
Glenside, PA 19038

Beaver College
Graduate Studies

A Program to Retrain Teachers in Mathematics

Long Island University's
Model Mathematics Retraining Program
THA-MASTER
FIPSE FUNDED
and
The Master of Arts in
Education Degree Program
Beaver College

A Program to Retrain Teachers in Mathematics

This mathematics program is designed as both a retraining program for teachers and a program to enhance the background of teachers in the field. It is scheduled to begin in the Spring of 1985.

PROGRAM HIGHLIGHTS

- ...on reduced in all mathematics courses
- ...aduate courses specifically designed for non-mathematics majors
- Unique course schedule and contact hour plan
- 18 credits in mathematics
- Lectures and small group discussions
- Opportunity for employment in Philadelphia and in the Delaware County Area
- Opportunity to qualify for the M.S. in Education Degree
- Opportunity for teachers certified in mathematics to increase their competence
- Opportunity for teachers not certified in mathematics to retrain and become certified to teach mathematics.

STAFF

Site Project Director: A. Richard Polis, Ed.D.
Dean of Graduate Studies

Other Staff Includes:

Edward F. Wolff, Ph.D.,
Associate Professor and Chairman of the Mathematics Department

Charles E. Moulton, Ed.D.,
Professor of Mathematics

Michael G. Gonzales, M.A. in Ed.
Assistant Professor of Mathematics

ADMISSION REQUIREMENTS

- Admission to the Beaver College Master's Program and/or Mathematics Certification Program
- Classroom experience as a teacher
- Admission to the Graduate Intern program for applicants without teacher certification
- Completion of at least six credits of college mathematics, including one semester of the Calculus

Since admission to the program is limited, applications should be submitted as soon as possible.

YEARLY SCHEDULE

The mathematics courses are offered as noted below. (See the Beaver College Graduate Studies Catalog for information about courses in Education.)

MA 501	Survey of Mathematics I	Spring
MA 502	Survey of Mathematics II	Summer
MA 503	Selected Topics in Calculus	Summer
MA 505	Selected Topics in Mathematics (Probability and Statistics)	Fall
MA 510	Selected Topics in Mathematics (Euclidean and Non-Euclidean Geometries)	Winter
MA 520	Introduction to Modern Mathematics	Spring

Beaver College admits qualified students of any age, race, color, national or ethnic origin, or handicapped as defined by law.

PROGRAM REQUIREMENTS FOR THE MASTER OF ARTS IN EDUCATION DEGREE (36 credits)

FOUNDATIONS COURSES IN EDUCATION (6 to 9 credits)

ED 401	Social Foundations of Education
ED 407	Philosophical Foundations of Education or
ED 409	Psychological Foundations of Education

CONCENTRATION IN MATHEMATICS (15 to 18 credits)

The courses in mathematics follow the Long Island University Model, THA-MASTER

MA 501	Survey of Mathematics I
MA 502	Survey of Mathematics II
MA 503	Selected Topics in Calculus
MA 505	Selected Topics in Mathematics I (Probability and Statistics)
MA 510	Selected Topics in Mathematics II (Euclidean and Non-Euclidean Geometries)
MA 520	Introduction to Modern Mathematics

SELECTED ELECTIVES (6 to 9 credits)

Selection of electives is made with advice from the Project Coordinator.

ED 457	Applications of Mathematics to the Physical Sciences
ED 469	Educational Applications of the Microcomputer
ED 433	Reading in Content Areas
ED 480	Introduction to Developmental Disabilities
ED 370	Designing Learning Environments
ED 420	Seminar for Graduate Interns

CULMINATING ACTIVITY (3 to 6 credits)

All students are required to take a practicum, ED 383, Graduate Internship, Secondary. The number of credits required will be determined by the Dean of Graduate Studies.

MATHEMATICS RETRAINING PROGRAM
BEAVER COLLEGE, GLENSIDE, PA 19038
PROJECT DIRECTOR - DR. A. RICHARD POLIS, 215-572-2960

I. EXECUTIVE SUMMARY:

A. PROJECT OVERVIEW: The mathematics retraining program at Beaver College has been in existance for ten years. In 1984 we agreed to use the THA MASTER PROGRAM design for one cycle to see if it met our needs. We were able to get support from the mathmematics and education faculty at Beaver College and approval from the Graduate Academic Program Committe. All courses were approved and a special master's program was designed with the six LIU courses at the core. We advertised and admitted 18 students to the program by January of 1985 and completed the six mathematics courses by June of 1986. Of the 18 original students, 13 are now certified mathematics teachers. We are halfway through a second cycle of this program and hope to certify another 18 teachers. We also anticipate a third cycle to begin in the fall of 1987.

B. PURPOSE: To retrain experienced and certified teachers to become certified in mathematics. To offer financial support in the form of partial or full scholarships to teachers who wish to retrain. To produce better qualified teachers of mathematics for the Commonwealth of Pennsylvania.

C. BACKGROUND AND ORIGINS: Beaver College has a long history of innovation in teaching and has worked closely with the public schools in the Delaware Valley area. We have a strong committment to mathematics and mathematics education, fine faculty, and interest in continuing to provide excellent teachers of mathematics for the schools of the Commonwealth. There was and is support for this project in the college.

D. PROJECT DESCRIPTION: We started the project with four of the six project courses and two modified courses. We now offer seven courses plus a computer science course and have increased emphasis in algebras, geometries, probability, statistics, discrete mathematics and computer science. We have modified the timetable and offer four courses by using fall, winter, spring and summer terms with courses in 15 week, 12 week and six week slots. We have begun to hire student tutors who are certified mathematics teachers to lead study groups and tutorials. As part of our organizational pattern, we now have an advisory group made up of students, faculty and public school people.

E. Project Results: We have completed one cycle, are in the middle of a second cycle and plan a third cycle. We have been funded by several agencies to do retraining and upgrading of teacher in mathematics and science. Our students have been quite successful in school and in the job market. Our attrition rate was approximately 25% in cycle one and 33% in cycle two. Dissemination included press releases, 10,000 mailings, five papers given at state and national meetings.

F. SUMMARY AND CONCLUSIONS: The THA-MASTER is an excellent beginning program for training entry level mathematics teachers. We modified the courses to offer our teachers more mathematics content and these modifications prepare teachers to do a high quality job of teaching up to the 10th or even the 11th grade. I do believe that we spent more time thinking about better ways to educate mathematics teachers.

MATHEMATICS RETRAINING PROGRAM
BEAVER COLLEGE, GLENSIDE, PA 19038
PROJECT DIRECTOR - DR. A. RICHARD POLIS, 215-572-2960

I. FINAL REPORT:

A. PROJECT OVERVIEW:

Mathematics and mathematics-education has always been an area of strength at Beaver College. We have been retraining teachers into mathematics for the past ten years and have received national recognition for the model we used from 1976 to 1984. In the spring of 1984 Dr. Richard Polis gave a paper on retraining in San Francisco at the Annual Meeting of the National Council of Supervisors of Mathematics. Dr. Madelaine Long attended his session and discussed the FIPSE-THA-MASTER PROGRAM with him and suggested that Beaver College might want to be one of the site schools.

In the fall of 1984 Dr. Polis, Dean of Graduate Studies, Dr. Wolff, Chairman of the Mathematics Department and Dr. Rowe, Chairman of the Education Depratment met with Dr. Long and a few of the mathemtics faculty at the Brooklyn Campus of Long Island University. The faculty from Beaver College agreed that the program at LIU was unique, well designed, efficient and offered some benefits that our standard majors program did not offer. Clearly, seed monies to start the program seemed attractive and allowed Beaver to use this experimental program for one cycle without committing beyond that cycle.

In the fall of 1984 the program was supported by the mathematics and education faculty and approved by the Graduate Academic Program Committee. It was approved as an "experimental certification program" by the Pennsylvania Department of Education. The six mathematics courses were made part of a special master's degree program which also required six courses in professional education. This master's program was designed to meet state standards and to allow novice teachers to complete a full certification program through the Intern Teaching Model used in Pennsylvania. However, the major thrust was retraining of certified teachers.

By November of 1984 the program was advertised through press releases and by direct mail to local school districts. A brochure was designed and sent to secondary and elementary schools. Approximately 40 inquiries were made as a result of the advertising. Of the forty 18 applied and 17 were admitted. Of the 17 students in cycle one 13 have completed the program. A second cycle is in progress and a third cycle is planned.

B. PURPOSE:

The problem we face in the Philadelphia area is a shortage of qualified and certified mathematics teachers. The most talented people in mathematics at the undergraduate level no longer consider teaching as a viable career path. As a result, school districts have difficulty hiring highly qualified teachers of mathematics. The School District of Philadelphia is and has been in great need of high quality professionals. We were helping to meet this need through retraining of certified teachers and this project supported that major objective.

We did retrain teachers using a model that mixed undergraduate and graduate courses and produced mathematics teachers who had completed the traditional mathematics major. Our students were highly regarded and heavily recruited. Time and money were major problems faced by these students. They usually completed a program that ranged in credit from 42 to 60 hours of academic work. The LIU model allowed us to certify teachers after completeing 18 to 42 credits depending on their undergraduate training. Not only is the LIU model efficient in time, but support from FIPSE and other agencies have allowed us to offer full and partial scholarships to participants. The funding first by FIPSE through LIU and later by the State of Pennsylvania through Title II has helped considerably. In addition to the funding by FIPSE and the Federal Government, we have received support from local school districts.

The project addressed the problem of retraining. One of the major stumbling blocks to retraining seems to be funding. We have been able to find funds to solve this problem and believe that the original grant gave us leverage to seek and secure the necessary funds. We hope to continue our program by utilizing Title II and school district support.

C. BACKGROUND AND ORIGINS:

Beaver College has a long history of innovation in teaching and has worked closely with the public schools in our five county area. Our Writing Across the Curriculum Program, funded by FIPSE has received national recognition, as have other programs at the college. We have a rich history and reputation for high quality programs designed to train and retrain teachers in mathematics and science.

The Dean of Graduate Studies at Beaver College is a mathematics-educator who has authored several mathematics textbooks, has consulted for the Commonwealth and for school districts in and outside of Pennsylvania, has been active in local, state and national professional organizations in mathematics and has worked directly with the schools in the five counties in which Beaver College resides. In addition to his role as Dean, he is also the Certification Officer for the college. As Project Director, the Dean of Graduate Studies was able to see that the program approval process in the college and in the state was accomplished without too much red tape or opposition.

Beaver College has 75 full time faculty and 50 part time faculty who teach undergraduate day and evening and graduate day and evening courses. The Mathematics-Computer Science Department has six full time faculty and 15 part time faculty. This program has had little or no impact on number of faculty employed. We simply offered a course each semester and several in the summer. We did offer the courses in a different time frame than we offer our other classes. We utilized the winter break, summer school, and time bewteen graduation and the start of summer classes.

Our relationship with the School District of Philadelphia has always been solid. The Director of Mathematics in Philadelphia taught courses at Beaver and served on advisory committees. This new retraining program strengthened that relationship. We received funding from the school district to upgrade teachers of mathematics who are already certified, and we utilized some of the courses in the retraining program for that purpose. In addition to funding for upgrading, we recently received some funds to support the second cycle of this program.

D. PROJECT DESCRIPTION:

When we started this retraining program we approved six new courses: MA 501 Survey of Mathematics I, followed the LIU outline; MA 502 Survey of Mathematics II, was primarily a course in linear algebra, matrices, and transformations; MA 503 Selected Topics in Calculus, follows the LIU outline; MA 505 Selected Topics in Mathematics(Probability and Statistics), covers work in probability and sets the foundation needed in statistics; MA 510 Selected Topics in Mathematics (Euclidean and Transformational Geometries), is a modern geometry course; MA 520 Introductioon to Modern Mathematics, followed most of the LIU outline but did more with modern algebra.

We did not offer the Refresher Course nor did we approve Applied Calculus I, since we required six hours of college mathematics including at least one course in calculus for admission. The students in our first cycle were very bright, and for the most part academically talented. All but two had taken calculus in college. Therefore, we did not need to offer a refresher nor did we need to offer the fisrt calculus course. We were funded by the Commonwealth through Title II funds for retraining teachers into mathematics and started the scond cycle in the spring of 1986. Realizing that we could not recruit teachers in a short time who had the mathematics background that our first cycle students had, we modified the sequence and the content of the program.

Here is a description of that modification. We offered MA 501 first and emphasized pre-calculus mathematics, including the function concept as central to the course. We offered MA 502 next with little or no change. Instead of offering MA 503 next, we put it off and offered MA 510 so that we could arrange a calculus course to be given prior to MA 503. Since the Mathematics Department did not want the first calculus course to be given for graduate mathematics credit, we offered that course as Ed 427, Topics in the Teaching of Mathematics: Teaching Calculus. Ed 427 is being given this winter and will be followed by MA 503 in the spring. The students in cycle two will complete MA 505 in the summer and MA 520 in the fall. MA 520 has been developed into a modern algebra and number theory course in which content is combined to cover major ideas from both content areas. Finally, we believe that all students need a course in computer science. We have been using BASIC language for that purpose, but plan to require PASCAL in the future.

In the third cycle we plan to redesign MA 502 and retitle the course as Discrete Mathematics. Part of the reason for this has to do with the national emphasis on discrete mathematics and part has to do with requests we receive from local school districts.

In addition to changes in course content, order and emphasis, we have decided that the best timetable for this program at Beaver is to offer a 15 week course in the fall semester, a winter course that begins in January and meets twice weekly for one month and then once a week for two months. We follow this with a fifteen week course given from the middle of March to the end of June. In the summer we offer one course in the five week period. This allows students to complete four courses a year without too much time pressure.

We have begun to hire student tutors who are certified mathematics teachers. These tutors attend class with the students and hold tutorial study group sessions with 6 to 8 of the teachers who are retraining. The format varies from problem review and explanation of concepts to examination review. The students make up their own study groups and meeting times. We provide space and pay the tutors. This was made possible because of the funding level we received through Title II.

As part of our organizational pattern, we now have an advisory group made up of students, former students, faculty, and school district mathematics coordinators. Many of the program changes resulted from suggestions from this advisory body.

E. PROJECT RESULTS:

This project has resulted in two distinct certification tracks, our original mathematics major model and the experimental retraining model. Since we cannot afford both of these models, we will probably phase out the majors model for retraining and only use it for pre-service undergraduates. We have received grants for retraining in mathematics and chemistry, as well as a grant to upgrade the background of certified teachers. These grants are clearly related to the work we did in the first cycle of this project. We believe that we would not have been successful in our bid for funding without the experience of working with the project and the various site directors.

Dissemination was accomplished through several different vehicles. We used press releases in the local newspapers and in professional newsletters. We mailed over 10,000 brochures over a two year period and we sponsored colloquia and conferences in conjunction with the local professional mathematics organization whose members number over a thousand. In addition to this, the project director gave papers at several conferences. The papers are listed here.

1987 Pennsylvania Council of Teachers of Mathematics, March, 1987, Harrisburg, Pennsylvania, "Retraining of Teachers in Mathematics: The Tip of the Iceberg."

1986 THA-MASTER Dissemination Conference, December, 1986, Puerto Rico, "Retraining of Teachers in Mathematics: The Tip of the Iceberg."

1986 Pennsylvania Council of Teachers of Mathematics, March, 1986, Pittsburgh, Pennsylvania, "Retraining of Teachers in Mathematics."

1986 Conference for Leaders in Mathematics Education, May, 1986, The Pennsylvania State University at Harrisburg "Procedures for Change in Mathematics Curriculum", Discussion Leader.

1985 Pennsylvania Council of Teachers of Mathematics, March, 1986, Valley Forge, Pennsylvania, "Retraining of Teachers in Mathematics."

1985 National Council of Supervisors of Mathematics, April , 1985, SanAntonio, Texas, "Probing for Excellence in Mathematics Teacher Retraining Programs."

A third outcome of importance is the use of the retraining courses in the grant to upgrade the training of certified teachers of mathematics. Not only did we receive a grant from the state to do this work, we received grants from the school district of Philadelphia. We have been funded by various agencies over the last two years for over $300,000.00 in grants and contracts related to retraining of mathematics and science teachers. Basic to our various initiatives has been the first grant through FIPSE and LIU.

The evaluation package which we used in cycle one of this project was weak. Therefore, we have very little data about the first group to complete the program. We designed a stronger evaluation package for the second cycle including our own pre and post-test of mathematical knowledge, along with an instrument to measure attitude toward mathematics. The data for second cycle is not available at this time. We did use these instruments for evaluation of our program to upgrade the training of mathematics teachers and found measurable increases in knowledge and positive attitude changes. The instruments are found in Appendix 5.

The only clear data on the students who completed the program is that 13 of the 17 who enetered completed the program. Of the 13 who completed 9 receieved grades of "A" in all of the mathematics courses or received grades of "A" in all but one mathemtics course. Of the 13, 7 now have positions teaching mathematics. We are planning to have these students and others take the mathematics portion of the NTE so that we can compare their reults to national norms.

F. SUMMARY AND CONCLUSIONS:

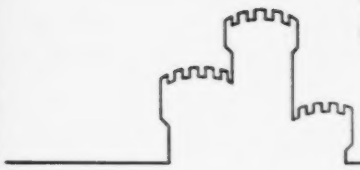
The THA-MASTER is an excellent beginning program for training entry level mathematics teachers. We modified the courses to offer our teachers more content in geometries, algebras, probability, statistics and computer science. We believe that our modifications prepare teachers to do a high quality job of teaching up to the 10th or even the 11th grade. We believe that these teachers need to do more work in mathematics if they wish to teach advanced high school courses. However,

we believe that their training may be superior to the traditionally trained mathematics major.

I am not sure that our ideas changed radically due to the program. I do believe that we spent more time thinking about better ways to educate mathematics teachers. The model we use now is in transition. We hope that we will never be satisfied with what we have and will always try to improve.

APPENDIX 4 Publicity

This letter and our brochure were sent to surrounding schools
To staff training personnel, Beaver mathematics faculty
Over 500 sent to appropriate personnel in Philadelphia School District



Beaver College

November 19, 1984

Dear Colleague:

Beaver College has been active in retraining teachers in a number of areas including mathematics and science over the past five years. Because of our reputation in this field, we have been asked to participate in a program that is being replicated nationally: "Long Island University's Model Mathematics Retraining Program, THA-MASTER, FIPSE Funded." We are starting a new cycle of this program at Beaver College in the spring of 1985 and have space for approximately twenty (20) qualified applicants.

The program is designed to either recertify teachers in mathematics, upgrade the skills of certified teachers of mathematics or certify liberal arts graduates in mathematics.

If you know of any suitable candidates for this program in your district you may want to pass this information along to them. We have enclosed several copies of our brochure explaining the program.

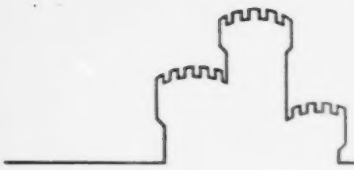
If you have any questions please do not hesitate to call me at 572-2960.

Sincerely yours,

A. Richard Polis
Dean of Graduate Studies

ARP/mg
Enc.

EASTON and CHURCH ROADS/GLENSIDE/PENNSYLVANIA 19038 (215) 572-2900



Beaver College

P R E S S R E L E A S E

President Bruce Wilson of Beaver College announced today that, through the efforts of Dr. A. Richard Polis, Dean of Graduate Studies, Beaver has been selected as one of the five national sites funded by Long Island University through a grant from FIPSE (the Fund for the Improvement of Post Secondary Education).

The grant will support an innovative program designed to retrain teachers in mathematics, upgrade inservice mathematics teachers, and certify a select group of liberal arts graduates with no background in education. All applicants must have a bachelor's degree and at least six credits in undergraduate mathematics including one course in calculus.

The program, to begin in the spring of 1986, will be scheduled in a way that will allow students to complete six graduate mathematics courses along with necessary courses in professional education by the end of spring 1986. Those who wish to receive certification in mathematics as well as a Master of Arts Degree may complete both as part of this innovative program. The M.A. in Education with a concentration in mathematics requires 36 credits, half in mathematics and half in professional education, plus a practicum. The courses in Education meet the General Standards and the mathematics courses meet the Specific Standards of the Pennsylvania Department of Education. The program is designed both for initial training of mathematics teachers and for upgrading the background of mathematics teachers already in the field. This program is considered to be a national model and is being implemented in five states: New York, Kentucky, Miami, Maine, and Pennsylvania.

Dr. Madeleine Long is the Director of the Project at Long Island University and will be talking about this model in the spring at meetings of the Pennsylvania Council of Teachers of Mathematics and at the National Council of Supervisors of Mathematics. For information and applications call 572-2959 or write Beaver College, Graduate Studies Office, Glenside, Pa. 19038.

EASTON and CHURCH ROADS/GLENSIDE/PENNSYLVANIA 19038 (215) 572-2900

APPENDIX 6

BEAVER COLLEGE

MATHEMATICS RETRAINING PROGRAM

LONG ISLAND UNIVERSITY'S

THA-MASTER

FIPSIE FUNDED

BUDGET 1985-86

FACULTY SALARIES

MA 501	Spring, 1985		$2,000.00
MA 502	Summer, 1985		$2,000.00
MA 503	Summer, 1985		$2,000.00
MA 505	Fall, 1985		$2,000.00
MA 510	Winter, 1985		$1,750.00
MA 520	Spring, 1986		$2,000.00
		TOTAL	$11,750.00
Director's Travel			$1,500.00
Advertising			$750.00
		TOTAL	$14,000.00
FIPSE CONTRIBUTED			$13,150.00
BEAVER CONTRIBUTED			$850.00

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NORTHERN COLORADO UNIVERSITY

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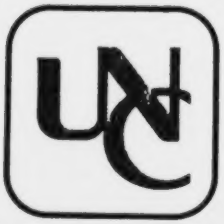

A Program to Retrain or Enhance Training in Physics Teaching

The Hellman Academy for Mathematics and Science Teacher Education Retraining (THA-MASTER)

Long Island University's Model Program Disseminated to the University of Northern Colorado by support from the Fund for the Improvement of Postsecondary Education (FIPSE).

University of Northern Colorado

A Program to Retrain or Enhance Training in Physics Teaching

This program is designed to both retrain teachers from other disciplines and enhance the training of teachers currently in the physical sciences. The emphasis will be directed toward those who will be teaching physics concepts in junior or senior high school. The program will begin mid-summer 1985.

Program Highlights

- Reduced Tuition in all program courses.
- Graduate courses specifically designed for teachers with limited preparation in physics.
- A pre-program preparatory course.
- 21-23 credits (quarter) in physics from UNC.
- Unique course scheduling over 15 months.
- Offered in metro-Denver area.
- Conceptual content presented through integrated learning activities.
- Opportunity to paritally fulfill requirements for Interdisciplinary Masters in Science Teaching (UNC).
- Opportunity for teachers to partially fulfill science endorsement requirements.

Staff

Site Project Director: Paul A. Lightsey
Associate Professor and Chairperson of Physics

Other Staff:

Wallace Aas, Professor of Physics
Willard Fadner, Professor of Physics
Richard Fry, Professor of Physics
Robert Hamerly, Professor of Physics

Eligibility Requirements

- Teachers with regular classroom experience.
- Teachers seeking certification or recertification with science endorsement.
- Teachers with at least one year of college science and one term of college mathematics.

Coursework

Preparatory Course
(3 credits)
Mechanics
(4 credits)
Heat, Sound, and Light
(4 credits)
Electricity and Magnetism
(4 credits)
Modern Physics
(4 credits)
Problems in Teaching Physics
(4 credits)

For additional information or applications write:

Paul A. Lightsey, Chairperson
Department of Physics
University of Northern Colorado
Greeley, CO 80639
Telephone: 351-2961

Since admission is limited, application should be submitted as soon as possible

The University of Northern Colorado is fully committed to Affirmative Action and Equal Opportunity

Sites Offering THA-MASTER

Information regarding these sites can be obtained by contacting:

Long Island University
Dr. Madeleine J. Long
Institute for the Advancement of Mathematics and Science Education
One University Plaza
Brooklyn, N.Y. 11201
(718) 403-1056

Beaver College
Dr. A. Richard Polis
Office of Graduate Studies
Easton and Church Roads
Glenside, Pa. 10938
(215) 572-2900

University of Miami
Dr. Gilbert J. Guevas
School of Education and Allied Health Professions
P.O. Box 248605
Miami, Fl. 33124
(305) 284-4301

Arizona State University
Dr. Lehi T. Smith
Department of Mathematics
Tempe, Az. 85287
(602) 965-3951

Texas Woman's University
Dr. Rose Marie Smith
Chairperson, Department of Mathematics, Science, and Computer Science
P.O. Box 22865
TWU Station
Denton, Tx. 76204
(817) 566-6335

University of Northern Colorado
Dr. Paul A. Lightsey
Department of Physics
Greeley, Co. 80639
(303) 351-2961

Western Oregon State College
Dr. Robert Main
Department of Mathematics
345 Monmouth Avenue, North
Monmouth, Or. 97361
(503) 838-1220 ex. 4432

Trenton State College
Dr. Michael Iannone
Office of Academic Affairs
Hillwood Lakes CN 550
Trenton, N.J. 08625
(609) 771-2269

Please send an application and additional information for THA-MASTER Program.

☐ I would like to speak with an advisor.

Best time to call _____

Please Print

Name _____

Address _____

City _____ State _____ Zip _____

Telephone Home _____ Business _____

FINAL REPORT: THA-MASTER Program at the University of Northern Colorado

The program activities and results are summarized in attachment 1, a paper presented at the San Juan Conference. All of the funded activities have been completed. The financial expenditures are presented in attachments 2 and 3.

Additional comments upon reflection:

> The participants apparently benefitted greatly from the program. However, a one year exposure to physics is not going to prepare excellent physics teachers. Evidence suggests that learning physics by adults may be a slower process than for adolescents due to "misconception" filters. We observed this phenomenon during the course of the program. A slower pace and more effort at identification of misconceptions will be valuable in future courses. Also, the slower pace may alleviate the high stress placed on these individuals while continuing their full-time employment. The high stress exacerbates the drop-out rate among those that have anxiety characteristics. The survivors of this program had a significantly better prior exposure to math and physics than did those that dropped out. Initially, this program may best serve the needs of schools by retraining those with some limited background in physics, rather than those with no physics background.

Future Activities:

> The University of Northern Colorado has incorporated the THA-MASTER curriculum into the Interdisciplinary Science Teaching Masters Degree Program. The courses are now offered on campus primarily during the summer term. Efforts to offer an off-campus program again are under way. Financial support for teachers from rural areas to attend the summer program and to suplement the off-campus program is desired and being sought.

While this program has been successful, it has also revealed the challenging and great task still remaining to meet the need of having quality physics teachers available in all schools in the USA.

Paul A. Lightsey, Site Director
THA-MASTER @ UNC

A Strategy for Retraining of Teachers for Physical Science

Paul A. Lightsey and Wallace Aas

INTRODUCTION

Concern over the shortage of science teachers, especially those in physical sciences, has been expressed in many forums. Various recruitment techniques to fill thin ranks have been proposed. Long term solutions have addressed ways to enhance the desirability of science teaching as a career to be considered by today's youth. Short term solutions have addressed ways to attract current professionals into the science classroom.

Two divergent methods have been suggested to recruit these professionals. One method is to attract individuals with science/engineering backgrounds to step into the classroom. Some proposals have involved temporary, visiting assignments by scientist/engineers to aid current teachers, or teach part-time in critical courses such as physics or calculus. Other proposals have aimed at recruiting scientists/engineers who are retired or near-retirement to consider a "second-career" as a science teacher. However, these proposals face the problem of re-training these professionals to have adequate knowledge and skills for the educational environment in the secondary science classroom.

The second method has looked at retraining current teachers from other disciplines into teaching in the sciences. The criticism of this method has been based on the assumption that retraining these teachers to gain adequate knowledge of the content and skills of physical science would be very difficult and that they would not develop an enthusiasm and love for the discipline because of their own "anxieties" about learning physics. However, these teachers have experience and the prerequisite training in teaching in the education environment at the secondary level.

PROGRAM PHILOSOPHY

This paper presents a strategy that attempts to overcome the criticisms of second method and successfully retrain teachers from other disciplines to be able to teach physics and physical sciences in the secondary classroom. To do this, a philosophy was adopted that the process of teaching the content and problem solving skills exemplified in physics to these teachers should be a model for them to use in teaching, i.e. to teach as they were taught. Recognizing their potential anxieties and "fear of physics", this model had to address ways to overcome pre-existing misconceptions and alleviate anxiety while bringing comprehension of physical science to an adequate level for them to step into the classroom with confidence and enthusiasm. Master high school physics teachers were included on the staff to provide effective teaching models for the high school classroom. The physics content covered the traditional subdisciplines. However, processes for analysing information and gaining insight into a content area were emphasized, so that these teachers would feel confident at moving into new areas on their own, rather than teach "rote information" from a text. In addition, the courses were to be offered over a fifteen month period, allowing participants to continue in full time employment while completing 20-23 credits (quarters).

NEEDS ASSESSMENT

Need for this program was assessed in a step-wise process. Initially a survey questionaire was sent to the administrators at 220 senior high and 185 junior high schools through out Colorado. Approximately 11% (43) of the forms were returned. These 43 respondents estimated that in their districts approximately 25 teachers were assigned to teach physics or physical science with less than one-year of college physics preparation, and approximately 60 teachers would benefit from participation in this program. Incentives or rewards for a teacher to participate in the program identified by these administrators were: salary increments (40%), job security (33%) recognition (9%), self-satisfaction and better understanding of physics (9%).

These administrators indicated that 33% of the districts would be willing to aid in retraining through stipends, released time, etc. and estimated that approximately 43 teachers would be willing to participate and provided 40 names of potential participants.

For logistic reasons, the first offering of this program was focussed on the high-population density Front-range area centered around Denver. The next step in assessing needs was to send brochures to all names suggested by respondents to the survey, to all school districts in the Front-range, to names on mailing lists of science teachers in the Denver area, and to individuals requesting information about the program. From these brochures, we received 77 requests for application materials (31 female, 46 male). We screened the applications to determine the number who had the required minimum math and science backgrounds, but who did not have extensive preparation in physics. Twenty-eight participants (11 female, 17 male) were accepted into the program.

PARTICIPANT PROFILES

The background of the participants was varied, though dominated by 15 individuals having majored in Biology. Other undergraduate majors represented were: 1 home economics, 1 physical education, 1 industrial arts, 1 physical geography, 1 earth science, 2 mathematics, 2 science education, 2 chemistry, and 2 physical science. The 4 in physical science and chemistry petitioned to be included even though they had previous preparation in physics. All four had received their degrees over twenty-years ago and desired a "refresher". The other 25 participants averaged 5 semester credits in physics preparation, compared to an average of 28 semester credits in biology, 13 semester credits in chemistry, and 11 semester credits in earth science. Fourteen of the participants had math preparation through at least introductory calculus, 11 others had at least college algebra, and 3 technical or general introductory math.

This data collectively demonstrated the need for a retraining program. In particular, there seems to be a cadre of biological science teachers interested in moving into physical science teaching.

CURRICULUM

The first course in the program is a preparatory course. This course reviews some basic algebra and trigonometric manipulation, then emphasizes quantitative problem solving through graphical analysis, making estimations and model

calculations ("Fermi problems"), and utilizing verbalization and feedback (e.g. see Clements & Lockhead). This course is delivered as a two-week intensive workshop during the summer.

The sequence of four content courses are offered over 12 months in a format of 12 repeating three week patterns consisting of a Thursday evening during week 1, an intensive all-day Saturday at the end of week 2, and a Thursday evening during week 3. A week of individual study typically separated each 3 week cycle. The Saturday classes incorporate laboratory activities extensively.

The nominal content is structured around the typical sequence of Mechanics; Light, Heat and Sound; Electricity and Magnetism; and Modern Physics. The high school master physics teachers are used to help structure the course so that the college level physics learned by the students can be applied to teaching activities encountered in the high school classroom.

The final course is a seminar in "Current Problems in Teaching Physics". This course reviews the recent literature as it relates to perception difficulties students have with physical phenomena, the concepts of cognitive science applied to physics instruction, and the discussions of the role of physics within the secondary school curriculum.

EVALUATION

The key to this strategy hinges upon establishing that the participants gain an understanding of the content and have a feeling of confidence and enthusiasm for teaching physics.

To demonstrate the comprehension of content, a pre-test and post-test were used. These were multiple-choice tests that covered the topics of the four content courses. The questions used for the pre- and post-test have been standarized nationally for students completing one-year of college-level physics.

The pre-test scores for the 28 participants averaged below the 20th percentile of students completing one-year of physics. One individual showed a pre-test comprehension equivalent at the 75th percentile level and six others were grouped in the 40 to 75 percentile region. The remaining 21 were below the 30th percentile.

Of the 28 participants that started, 14 (50%) completed the program. Those 14 that completed the course had a pre-test average at approximately the 20th percentile, while the other 14 had an average at about the 12th percentile. The post-test scores of those that completed the course showed improvements with one above the 90th percentile and two others above the 75th percentile. Five were in the 30-75 percentile and three remained below the 20th percentile.

The non-finishers were 9 Biology, 1 Math, 1 Home Economics, and 1 Science Education major. The finishers typically had 8 semester hourse more physics preparation than did the non-finishers, and the math preparation was similar.

The enthusiasm and confidence level were measured by a self-evaluation done by the participants in response to a questionaire upon completion of the program.

There were also standard course-evaluations completed by the students at the completion of each course. These evaluations provided feed-back about the students perceptions of the appropriateness of the courses and the extent to which the program was meeting their goals.

COMMENTS

This program has been successful in this format in the populated metropolitan area. However, a severe need for this type of retraining exists in Colorado and many other western states in the rural school districts. Typically, the science teachers in these rural districts must cover two to four content areas (e.g. some rural districts have one science teacher for all science, grades 7-12.) In addition, these teachers typically receive lower salaries (by differentials as large as 50% of metro salaries). These rural districts typically have a single high school serving a geographical area greater than 350 square miles and a student population less than 50 per grade level. Therefore, a program cannot draw an adequate number (15-20) of teachers to a central location (commute distance less than 50 miles) to participate. Possible modifications of this program would be to offer a summer program on campus. However, this model would require funding for subsidizing the relocation and housing costs of these low paid teachers to move 100-400 miles each summer and then return. Another possible model would be to utilize telecommunications, computer assisted learning, and pre recorded video materials. However, this model would also require substantial funding and creative adaptation to still incorporate the "teach as you were taught" and hands-on laboratory experiences. This model does offer the potential for the most radical innovations to occur, and perhaps provide beneficial models for exploitation of these technologies for other educational settings.

ACKNOWLEDGEMENTS

Funding to assist in this program was provided by the U.S. Department of Education through a Fund for the Improvement of Post-Secondary Education grant, administered through Long Island University. The authors especially wish to acknowledge the support by the grant project director, Dr. Madeleine Long of Long Island University. Appreciation also goes to Courtney Willis, David Reid, and Steven Iona, participants in the Physics Teacher Resource Agent program of the American Association of Physics Teachers (NSF funded) who contributed greatly as "master physics teachers." Finally, appreciation to Di Smyce of the Continuing Education Office and Sandy Hohnbaum and Donna Bunting of the Physics Department at the University of Northern Colorado for the administrative support to deliver this program.

0250P

PROBLEM: SHORTAGE OF SECONDARY PHYSICS TEACHERS

SOLUTIONS:

1) RECRUIT SCIENTISTS/ENGINEERS INTO CLASSROOM

   STRENGTH: WELL PREPARED IN CONTENT KNOWLEDGE

   WEAKNESS: A) LACK EXPERIENCE AND/OR KNOWLEDGE FOR COPING WITH SECONDARY CLASSROOM ENVIRONMENT.

   B) DIFFICULT TO COMPETE WITH INDUSTRIAL SALARIES.

2) RECRUIT RETIRED SCIENTISTS/ENGINEERS INTO CLASSROOM

   STRENGTH: WELL PREPARED IN CONTENT KNOWLEDGE

   WEAKNESS: A) LACK OF EXPERIENCE AND/OR KNOWLEDGE FOR COPING WITH SECONDARY CLASSROOM ENVIRONMENT.

   B) POPULATIONS OF AVAILABLE PARTICIPANTS UNKNOWN.

3) RETRAIN TEACHERS FROM OTHER DISCIPLINES

   STRENGTH: PREPARED FOR AND EXPERIENCED IN THE SECONDARY CLASSROOM ENVIRONMENT.

   WEAKNESS: A) WEAK PREPARATION IN CONTENT.

   B) SUSPECT ENTHUSIASM FOR THE DISCIPLINE.

SURVEY OF NEED:

220 HIGH SCHOOL AND 135 JUNIOR HIGH SCHOOL PRINCIPALS WERE SENT QUESTIONNAIRES, 43 RESPONDED.

Q1: HOW MANY TEACHERS CURRENTLY IN YOUR DISTRICT ARE TEACHING PHYSICS WITH 1 YEAR OR LESS OF COLLEGE PHYSICS?

25

Q2: IN YOUR OPINION, HOW MANY PARTICIPANTS WOULD BENEFIT FROM THIS PROGRAM?

60

Q3: WHAT KIND OF INCENTIVES OR REWARDS ARE THERE FOR PARTICIPATION?

SALARY INCREMENTS	40%
JOB SECURITY	33%
RECOGNITION	9%
SELF-SATISFACTION & UNDERSTANDING	9%

Q4: WOULD YOUR DISTRICT AID IN RETRAINING THROUGH STIPENDS, RELEASED TIME, ETC?

YES 33%

40 INDIVIDUAL TEACHERS IDENTIFIED FOR PARTICIPATION BY THESE 43 ADMINISTRATORS.

Program Philosophy

Process of teaching physics content to these teachers should be a model of teaching that they can use.

"Teach as they were taught"

The program should:

1) Help identify misconceptions that are a "confusing filter" to developing concepts of physics.
2) Utilize effective problem solving skill building.
3) Rely on observation of phenomena to develop abstract conceptual models.
4) Reduce anxiety about physics being "hard".
5) Build confidence and enthusiasm.
6) Be offered at a place and schedule that allows continued full-time employment.

Curriculum

Preparatory Physics

Physics I: Mechanics

Physics II: Heat, Sound, and Light

Physics III: Electricity and Magnetism

Physics IV: Modern Physics

Science Education: Current Problems in Teaching Physics

Course Schedule (16 months)

Preparatory Physics: Two-week workshop, four hours/day

Physics I-IV: Four week cycle repeated 12 times

Week 1: 4 hours, Thursday evening

Week 2: 3 hours, Saturday

Week 3: 4 hours, Thursday evening

Week 4: Self-study

Science Ed: 4 hours, Thursday evenings (10 weeks).

EVALUATION:

1) STUDENT CONTENT COMPREHENSION WILL BE BY STANDARDIZED POST-TEST AND CLASS PERFORMANCE.

2) STUDENT ENTHUSIASM, CONFIDENCE, AND SELF-SATISFACTION WILL BE BY QUESTIONNAIRE.

3) PROGRAM STRUCTURE, CONTENT, AND DELIVERY WILL BE BY QUESTIONNAIRE.

QUESTION & COMMENT:

HOW CAN THIS PROGRAM, IF AS SUCCESSFUL AS ANTICIPATED, BE MODIFIED TO REACH THE TEACHERS IN RURAL AREAS.

CHARACTERISTICS OF THE PROBLEM:

1) ONE-TO-FOUR SCIENCE TEACHERS FOR DISTRICTS THAT GRADUATE LESS THAN 100 STUDENTS PER YEAR AND COVER 300-400 SQUARE MILES.

2) SALARIES VERY LOW, OFTEN 50% OF METROPOLITAN AREA SALARIES.

PARTICIPANT PROFILES / GRAD PROFILES
(11 FEMALE, 17 MALE) / (4 FEMALE, 11 MALE)

UNDERGRADUATE MAJORS:

BIOLOGY	15 / 7	MATHEMATICS	2 / 1
CHEMISTRY	2 / 1	PHYSICAL GEOGRAPHY	1 / 1
PHYSICAL SCIENCE	2 / 2	PHYSICAL EDUCATION	1 / 1
EARTH SCIENCE	1 / 1	INDUSTRIAL ARTS	1 / 1
SCIENCE EDUCATION	2 / 0	HOME ECONOMICS	1 / 0

SCIENCE PREPARATION:

	BIOLOGY	CHEMISTRY	EARTH SCIENCE	PHYSICS
SEMESTER CREDITS	23	13	11	5

MATH PREPARATION:

INTRODUCTORY CALCULUS OR BEYOND	14 / 9
COLLEGE ALGEBRA, TRIGONOMETRY, OR PRECALCULUS	11 / 4
TECHNICAL OR GENERAL MATHEMATICS	3 / 2

PRETEST: / POSTTEST

STANDARDIZED AGAINST STUDENTS WHO HAVE COMPLETED ONE YEAR OF COLLEGE PHYSICS.

PERCENTILE	PRETEST(ALL)	PRETEST(DROPS)	PRETEST(GRADS)	POSTTEST
91 - 99	0	0	0	1
73 - 91	1	0	1	2
20 - 73	6	2	4	5
20 - 33	4	1	3	3
0 - 20	16	9	7	4
	27	13	15	15

Budgeted Expenditures: THA-MASTER, University of Northern Colorado

				Balance
SCI	508	Refresher Course (3 Q.H.)		
		Wallace Aas, Instructor	1178.08	
				1178.08
SCI	515	Physics I (4 Q.H.)		
		Paul Lightsey, Instructor	1570.79	
		Wallace Aas, Assistant	785.40	
		Courtney Willis, (honoraria)	112.20	
			2468.39	
				3646.47
SCI	516	Physics II (4 Q.H.)		
		Wallace Aas, Instructor	1570.79	
		Ralph Engardt, Assistant	700.00	
		Courtney Willis, (honoraria)	112.20	
		David Reid, (honoraria)	112.20	
			2495.19	
				6141.66
SCI	517	Physics III (4 Q.H.)		
		Paul Lightsey, Instructor	1570.79	
		Courtney Willis, Assistant	785.42	
		David Reid, (honoraria)	112.20	
			2468.41	
				8610.07
SCI	518	Physics IV (4 Q.H.)		
		Paul Lightsey, Instructor	1570.79	
		David Reid, Assistant	785.42	
		John Tretney, (honoraria)	112.20	
			2468.41	
				11078.48
SCED	680	Problems in Teaching Physics (4 Q.H.)		
		Paul Lightsey, Co-instructor	1178.11	
		Wallace Aas, Co-instructor	1178.11	
			2356.22	
				13434.70
		Site Director		
		Paul Lightsey	1683.03	
				15117.73
		Grant, Long Island University		
		FIPSE	-15100.00	
				17.73
		Insurance	100.12	
		Computer Usage	25.20	
				153.05
		UNC Credit	-153.05	
				-0-

THA-MASTER ROSTER

UNC

Allen Balczarek
,853 S. Coors Dr.
Lakewood, CO 80228
Ind. Arts
Skinner M.S.-ind art

Marsha Barber
1868 B South Ammons
Lakewood, CO 80226
Physical Geography
Deer Creek JHS - earth sci

Pete Brayton
2612 S. Logan #3
Denver, CO 80210
Biology
Arapahoe HS - physics

Cindy Church
Biology Dept.
UNC
Greeley, CO 80639
Biology
GTA- biol

Julian Clark
8248 Acoma Way
Denver, CO 80221
Biology & Chemistry
Montbello HS - physics & e.s.

Ray Coddington
1868 Northview Dr.
Colorado Springs, CO 80909
Biology
Wasson HS - chen & biol

John Davidson
10110 W. Warren Dr.
Lakewood, CO 80227
Earth Science
Denver West HS - earth sci & physics

George Franklin
18942 E. Kansas Dr.
Aurora, CO 80017
Biology
Aurora MS - physical sci & life sci

Marshal Hanks
2925 S. Mobile Way
Aurora, CO 80013
Physical Science
Thomas Jefferson HS - chem & physics

Rodman Hayes
3450 Estes St.
Wheatridge, CO 80033
Biology
Ken Caryl JH - math

Ron Jones
3330 Mirage Dr.
Colorado Springs, CO 80918
Physical Science
Wasson HS - physics

Peggy McCoy
6516 S. Flower
Littleton, CO 80123
Biology
not teaching this year

Jack Simpson
5320 W. Kentucky Ave.
Lakewood, CO 80226
Physical Education
Denver PS - pe & ind art

James Skadden
7025 Defoe Ave.
Colorado Springs, CO 80911
Mathematics
Widefield HS - physics & astronomy

MaryAnn Varanka
P. O. Box 3173
Estes Park, CO 80517
Biology
Estes Park HS - chem & biol

College of Arts and Sciences
Department of Physics

University of Northern Colorado
Greeley, Colorado 80639
(303) 351-2961

December 17, 1984

Dear Colleague:

The shortage of physical science/physics teachers continues and will potentially worsen as many school districts increase graduation requirements in sciences. One way of reducing this shortage with relatively limited resources is to retrain teachers from other disciplines and to enhance the preparation of teachers currently teaching physical science/physics with limited background.

The Hellman Academy for Mathematics and Science Teacher Education Retraining (THA-MASTER) model program, has been developed and successfully implemented by the Brooklyn Campus of Long Island University. Funding for this program has been fron the National Science Foundation (NSF) and the Fund for Improvement of Post Secondary Education (FIPSE). The Physics Department of the University of Northern Colorado is proposing to implement this program as a dissemination site under FIPSE funding.

The program is for individuals who have classroom teaching experience, a minimum of one year of college level sciences, and a desire to either become or improve as a physical science/physics teacher. The first course in the program is a preparatory course to compensate for undergraduate deficiencies in physical science. This course does not carry graduate credit. Following are four courses that cover the essential content of physics integrated with pedagogic materials addressing appropriate techniques and materials to be used in grade levels 7-12. A final course on societal issues related to physics is presented. The courses are scheduled over a 15-month period: two summer sessions and the interim academic year.

We would appreciate your assistance in assessing the need for a program such as described above and help in identifying a pool of candidates to participate in this program by responding to the attached questionnaire.

Sincerely,

Paul A. Lightsey

Paul A. Lightsey, Ph.D.
Chairperson, Department of Physics

PAL/srw

The University of Northern Colorado is fully committed to Affirmative Action and Equal Opportunity.

UNC Physical Science/Physics Retraining Survey

Name:

Address:

Telephone:

School/District:

1. What are the current staffing needs in high school physics and high school/ junior high physical science courses in your school and/or district?

2. Approximately how many teachers in your school and/or district are currently assigned to teach physical science and/or physics classes, but have less than one year of college physics preparation?

3. How many teachers in your school and/or district having limited physics preparation would benefit from participation in a program as described?

4. What incentives or rewards would there be for such a person in your school and/or district to pursue this program (e.g. salary increments, job security, recognition, etc.)?

5. Would your district administration be willing to aid in retraining of these individuals through stipends, released time, etc.?

6. What would be your estimate of the number of teachers in your school and/or district who would desire to participate in this program.?

Please list the names and addresses of individuals that you feel would benefit and be interested in this program on the reverse side of this questionnaire.

Please contact me if you have any questions regarding this questionnaire or the program.

Questionnaire should be returned as soon as possible to:

Paul A. Lightsey, Ph.D.
Chairperson, Department of Physics
University of Northern Colorado
Greeley, CO 80639
Telephone: (303) 351-2961

College of Arts and Sciences
Department of Physics

University of Northern Colorado
Greeley, Colorado 80639
(303) 351-2961

April 26, 1985

Dear Colleague:

We are pleased to announce that the University of Northern Colorado has received a grant to implement a model program, THA-MASTER, for retraining teachers from other disciplines in physics/physical science or to enhance the training of those currently teaching in physics or physical science courses. A brochure is enclosed that further explains the program.

The grant will allow this program to be offered at a reduced tuition ($25.00/credit hour + course fees). The course fee structure has not been determined at this time, but negotiations are in progress to keep the cost to the participant low. Enrollment will be limited to 30 participants maximum, 15 minimum.

The courses will be offered in the Denver-Metro area in an evening and weekend format. The preparatory course will be scheduled two nights per week for five weeks starting in late July. The next three courses will be offered, one per quarter, through the academic year. These will be offered in a pattern of Thursday evening of week one, all day Saturday of week two, Thursday evening of week three, and week four off. Then repeat twice more for a total of eleven weeks. The last two courses will be offered next summer.

The courses will be focused on developing content knowledge and the associated observational and problem solving skills. This development will be achieved by classroom methods that can be models for the program participants to use in their own classrooms. The models will incorporate a multi-experience approach consisting of laboratory exercise, lecture-demonstrations, video, text and computer-assisted instructional materials, As fundamental physical concepts are developed, technological applications and related societal impact will be integrated into the course content.

The final course of the program will examine a series of topics related to science education. Some examples of such topics would be cognitive skills development, educational technologies, social-economic concerns related to equipment and supplies availability, teacher support system, minority student support systems, and alternatives to classroom experiences that might be developed through cooperation with industry.

The University of Northern Colorado is fully committed to Affirmative Action and Equal Opportunity

Please share this information with your colleagues. If you or your colleagues desire additional information and/or application forms, please contact:

Paul A. Lightsey
Department of Physics
University of Northern Colorado
Greeley, CO 80639
Telephone: 351-2961

Since admission is limited, interested candidates for this program should apply promptly.

Sincerely,

Paul A. Lightsey

PAL/db
Enclosure

TO: Persons expressing interest in THA-MASTER program.

FROM: P.A. Lightsey

DATE: May 22, 1985

Thank you for your interest in THA-MASTER program. An application form is enclosed. We will make initial selection of participants on June 14. Applications received after June 14 will be considered on a "space available" basis.

The preparatory course will run four hours a day, Monday through Friday for two weeks, Aug. 5 through Aug. 16. The remaining courses will run on a four week cycle during the academic year. The cycle will consist of a Thursday evening during week 1, all day Saturday at the end of week 2, Thursday evening during week 3, and week 4 free for self-study, recuperation, and regrouping as necessary. The courses will employ laboratory exercises, demonstrations, video, and computer assisted activities and encourage exploration of other effective learning strategies to be used "outside" of the scheduled class time. One of the goals is to have these techniques be useful to participants as models for their own teaching of physics.

If you have additional inquiries, please contact:

Paul A. Lightsey
Department of Physics
University of Northern Colorado
Greeley, CO 80639
Phone: 351-2961

University of Northern Colorado

THA-MASTER

The Hellman Academy for Mathematics and Science Teacher Education Retraining
Funded by The Fund for the Improvement of Post Secondary Education
United States Department of Education

1. Name _____

2. Address _____

3. Telephone Number _____

4. Business Address _____

5. Business Telephone Number _____

6. Social Security Number _____

7. Date of Birth _____

8. High School _____ Date of Graduation _____

9. Undergraduate University _____ Date of Graduation _____ Degree _____

10. Graduate University _____ Date of Graduation _____ Degree _____

Major _____ Minor _____

11. Mathematics courses taken in college (undergraduate and graduate).

Title	Credits	Grade	University	Date

12. Physics courses taken in college (undergraduate and graduate).

Title	Credits	Grade	University	Date

13. Other science courses taken in college (undergraduate and graduate).

Title	Credits	Grade	University	Date

14. Pertinent high school courses in mathematics and science.

15. Teaching Experience
Please list, starting with your current position, your teaching experience from 1981.

Position	School	Grade Level	Subject

16. If you are not currently teaching, or have not taught in the past five years, explain why.

17. List all Colorado Certification endorsements you hold.

_____

_____

_____

_____

_____

18. Briefly explain your reason for applying to this program.

_____

_____

_____

_____

19. Scores (if available): SAT _____ ACT _____ GRE _____

Transcripts of undergraduate and graduate study and two letters of recommendation should be submitted with this application to:

Paul A. Lightsey
Physics Department - Ross Hall
University of Northern Colorado
Greeley, CO 80639

Date _____ Signature _____

Interim Report: THA-MASTER

In February, 1985, the University of Northern Colorado Physics Department was selected as a site for the THA-MASTER Program administered by Long Island University and f nded by FIPSE. From previous surveys conducted by the UNC Physics Department, an off-campus program in the Denver metropolitan area was determined to be the most efficient in reaching the largest potential audience. A brochure advertising the program was distributed during the spring to all high schools and junior high schools in the metro area (brochure enclosed). Initial inquiries for application materials exceeded 50. Thirty-one applications were completed and 28 participants are currently enrolled in the program (10 female, 18 male). Class roster is enclosed.

The preparatory course was taught during August 1985. Cherry Creek High School was chosen as the delivery site being central to the Boulder, Denver, Colorado Springs area from which participants resided. A syllabus and class materials were prepared by Wallace Aas and was assisted by Paul Lightsey in the instruction of the course. (Sample set of materials enclosed along with class roster). This course was delivered in 10 afternoon sessions over a two week period. The students received three credits (quarter hours). The standard student evaluation survey instrument was administered upon completion of the class. Results will be forwarded at a later date (form enclosed).

The first content course, mechanics, started in September, 1985. The course is being taught by Paul Lightsey, with Wallace Aas assisting. In addition, Courtney Willis, a master high school teacher at the University of Northern Colorado Laboratory School is being used as a resource person in this course. The course is being taught in a Thursday evening, all-day-Saturday, Thursday evening format. The complete schedule for the first four courses is enclosed.

A standarized test over physics content was administered as pretest. A similar test will be administered as a post-test upon completion of the fourth content course. The results of the test indicate a deficiency in knowledge of physics by the class as a whole, consistent with the objectives of participant selection.

Student evaluation forms will be administered upon completion of each course. In addition, adaptations of the sample forms developed by Carole Kazlow will be administered to students upon completion of the third course (second content course), and sixth course. The instructor participation forms will be filled out by all faculty participating in the program.

Currently, $750 for project director salary has been encumbered for Paul Lightsey, and $1176 for instruction of the preparatory course have been encumbered for Wallace Aas. An additional encumbrance of $1568 for lecture, $784 for lab instruction, and $200 honoraria for inviting master teachers to make presentations is anticipated for each of the four content courses to be taught Fall, Winter, Spring and Summer Quarter. An encumbrance of $1176 for instruction and $200 honoraria is anticipated for the pedagogic course next summer. An additional encumbrance of $750 for project director is anticipated, leaving $1042 for a travel budget. Anticipated travel would be for Wallace Aas and Paul Lightsey to attend the March meeting of NSTA in San Francisco and for Paul Lightsey to attend the January meeting of AAPT in Atlanta.

The University

The University of Northern Colorado is uniquely qualified to provide retraining programs for teachers of Science. One of the major goals and missions of the University is the training of teachers. Indeed, UNC has long been recognized as a leader in this area and has been designated by the Colorado Commission on Higher Education as the premier teacher education institution in Colorado.

Most all academic departments at the University are involved in teacher preparation. This includes the Departments of Biology, Chemistry, Earth Science, and Physics which, in addition to having strong undergraduate programs leading to graduate and professional schools, take pride in training the secondary school science teachers for the state of Colorado. Furthermore, the faculties of each of these departments is involved with the supervision of student teachers which takes these faculty members to many of the schools state-wide and brings them into contact with many of the science teachers around the State. Because of this the faculty in Biology, chemistry, Earth Science, and Physics have close ties to high school science teachers and to secondary schools statewide. Furthermore, the science faculty provide much of the state leadership for organizations dedicated to excellence and innovation in science education such as the Junior Colorado-Wyoming Academy of Science, Colorado Biology Teacher's Association, National Science Teacher's Association, American Association of Physics Teachers, National Association of Geology Teachers, and the Education Section of the American Chemical Society. In addition the University and the science faculty have been responsible for providing summer educational experiences for outstanding upper level high school science students through the Frontiers in Science Institute which is funded by private industry located in Colorado. Additional long term interactions between the University and Colorado secondary schools include a summer program for gifted and talented secondary school students, a "College for Kids" summer program which includes innovative science courses, a science visitation day program for secondary school students and their teachers as well as annual education conference for Colorado and surrounding area educators. The faculty members participating in THA-MASTER program present lectures, demonstrations, and activities for these programs annually.

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PORTLAND, MAINE PUBLIC SCHOOLS

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PORTLAND PUBLIC SCHOOLS

Portland, Maine

LONG ISLAND UNIVERSITY MATHEMATICS PROJECT

Final Report

July 1987

Long Island Math Project
Portland Public Schools
Richard L. Whitmore
Assistant Superintendent/Secondary
331 Veranda Street
Portland, Maine 04103
(207) 775-0900

Project Context:

The context of this project is to fill the gaps in the Portland Public Schools' Math Department stemming from a national teachers shortage in mathematics. Prior to the funding, the project was nonexistent. The project is tending toward success given that two Long Island participants have already been placed in secondary mathematics positions. Also, given that the staff at Deering contained teachers qualified to teach the Long Island Project (LIP) has lead to its preliminary success. This peer-teaching-peer relationship is one of the most beneficial aspects of the Portland project due to the increased availability of the instructors to the students.

Our organization has 2,400 students and roughly 25 secondary mathematics teachers. The Portland Public School System enjoys a local, state, and national reputation for educational leadership and achievement. The school system is proud of its excellent program of study, good discipline, and renovated and new buildings. Alternative educational programs are available. Test results are aggressively used to improve student achievement, teaching, and administrative staff performance. There are active staff development programs for teaching excellence - the Long Island Math Project is one example. Because of such programs we were able to accommodate the LIP without significant changes in school policy or organization.

The best feature for Portland adopting LIP was having qualified instructors on the math staff capable of implementing the LIP objectives. Teachers Dorothy Kelleher and Larry Wheeler were well prepared to implement and to execute the program tasks.

The students in this Portland program consisted of teachers from elementary, middle and high school levels. Two teachers had degrees in mathematics; the remaining participants did not have math degrees. All participants expressed an interest in math and a desire to teach advanced secondary levels. It seems that they will be able to fulfill their goals through this project.

Funding came from the Portland Public School System and the participants besides Thamaster.

The Portland Public Schools guaranteed a minimum enrollment of twelve participants and would reimburse Long Island University $1,355 dollars per teacher per course. The teachers agreed to reimburse the Portland Public Schools $650.00 if they completed the six courses.

There were no major changes in timetables, emphasis, and support as outlined in the original project conception.

Backgroung and origins:

In the spring of 1984 we were approached by Long Island University to participate in the teacher training project. Dr. Madeleine Long, Director, Brooklyn University, Dr. Peter Greer, former Portland Superintendent of Schools and Mrs. Eve Bither, former Assistant Superintendent/Secondary met to discuss the program. After Dr. Long described the project it was decided that Portland would participate in the program. We began recruiting teachers to participate in the project. Due to a change in Assistant Superintendents, the project did not begin until September 1985 and ending in June 1987.

Project Results:

As a result of completing the project, two participants are teaching at the secondary level and two more anticipate entering math teaching during 1987-88.

Considerable math faculty interaction has resulted from LIP. A network of professional "helping" is evident among program participants. Dissemination is evident in secondary student achievement resulting from additional content acquired by participants.

****

TEXAS WOMAN'S UNIVERSITY

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I am interested in the THA-MASTER program at TWU.

Please send application and additional information on:

_____Program to Prepare Teachers in Mathematics

_____MA, MS, or MSSED degrees in Mathematics

_____Certification in Mathematics

For an appointment please call (817) 566-6335

Please print:

Name _____

Address _____

City _____ **State** _____ **Zip** _____

Telephone (___) _____ (___) _____
Business **Home**

Mail this form to: **Dr. Rose Marie Smith, Site Project Director, THA—MASTER**
Department of Mathematics, Computer Science, and Physics,
Texas Woman's University, Box 22865, Denton, Texas 76204

Texas Woman's University
Department of Mathematics,
Computer Science, and Physics

A Program to Prepare Teachers of Mathematics

Model Site

THA-MASTER
Long Island University
Model Mathematics Retraining Program

supported by

The Fund for the Improvement of
Postsecondary Education
(FIPSE)
Department of Education
1983-1986

A Program to Prepare Teachers of Mathematics

This program, developed in response to a critical need for mathematics teachers, offers a unique opportunity to a select group of students. Its purpose is to prepare persons to become junior and senior high school mathematics teachers. The program will begin during the second summer session of 1985 at Texas Woman's University in Denton.

The model for this program was developed at Long Island University and is now being offered at several sites across the country, where adaptions of the model are being incorporated. The resulting network is effectively using the model, which was designed for non-mathematics majors, to produce successful teachers of mathematics.

Program Highlights

- Graduate courses specifically designed for prospective teachers of mathematics
- Unique course schedule and contact hour plan
- 18 semester credit hours in mathematics
- Lectures and small discussion groups
- Individual academic counseling and advising
- Opportunity to qualify for the Master of Science or Master of Science in Science Education degree
- Opportunity to qualify for certification at the secondary level in mathematics
- Limited tuition scholarships available

Staff

Site Project Director: Dr. Rose Marie Smith
Chairman, Department of Mathematics, Computer Science, and Physics,
Texas Woman's University

Other TWU Staff Include:
Professor John Christy
Associate Professor Bobby Fincher
Associate Professor Turner Hogan
Associate Professor Lee Kennedy
Assistant Professor Frances Thompson
Lecturer Catherine Banks

Eligibility Requirements

- To be eligible for this program you must seek secondary certification, recertification, or additional certification in mathematics as a teaching field
- Have completed one year of college mathematics
- Qualify for admission to the Texas Woman's University Graduate School and/or Certification Program

Yearly Schedule

The mathematics courses offered are:

MATH 5903 Survey of Mathematics I	Sum II 1985
MATH 5903 Survey of Mathematics II	Fall 1985
MATH 5903 Applied Calculus I	Spring 1986
MATH 5903 Applied Calculus II	Sum I 1986
MATH 5903 Survey of Modern Math.	Sum I 1986
MATH 5903 History of Mathematics	Sum II 1986

In the operation and administration of the project and in the selection of participants, Texas Woman's University will not discriminate against any person because of race, creed, color, sex, age or national origin.

Other sites offering the THA-MASTER

Long Island University
Dr. Madeleine J. Long
Institute for the Advancement of Mathematics and Science Education
One University Plaza
Brooklyn, N.Y. 11201
(718) 403-1056

Beaver College
Dr. A. Richard Polis
Office of Graduate Studies
Easton and Church Roads
Glenside, Pa. 10938
(215)572-2900

Trenton State College
Dr. Michael Iannone
Office of Academic Affairs
Hillwood Lake CN 550
Trenton, N.J. 08625
(609) 771-2269

University of Miami
Dr. Gilbert J. Cuevas
School of Education and Allied Professions
P.O. Box 248605
Miami, Fl. 33124
(305) 284-4301

Arizona State University
Dr. Lehi T. Smith
Department of Mathematics
Tempe, Az. 85287
(601) 965-3951

Texas Woman's University
Dr. Rose Marie Smith
Chairman, Department of Mathematics, Computer Science, and Physics
P.O. Box 22865
Denton, Tx. 76204
(817) 566-6335

University of Northern Colorado
Dr. Paul Lightsey
Department of Physics
Greeley, Co. 80639
(303) 351-2961

Western Oregon State College
Dr. Robert Main
Department of Mathematics
345 Monmouth Avenue,
North Monmouth, Or. 97361
(503) 838-1220 ex. 443

Texas Woman's University

Department of Mathematics, Computer Science and Physics

A PROGRAM TO PREPARE TEACHERS OF MATHEMATICS

Model Site

THA-MASTER
Long Island University
The Model Mathematics Retraining Program

supported by

The Fund for the Improvement of
Postsecondary Education
(FIPSE)
Department of Education
1983-1986

Site Project Director:
Dr. Rose Marie Smith, Chairman
Department of Mathematics, Computer
Science and Physics
Texas Woman's University
Denton, Texas 76204

The THA-MASTER project entitled "A Program to Prepare Teachers of Mathematics" began at Texas Woman's University during the second summer session of 1985. Coursework continued during the fall of 1985 and spring of 1986. During these three semesters the participants were enrolled in two courses in precalculus and the first semester of introductory calculus following the curriculum of the Model Site. A graduate student worked with the participants to provide tutoring and other help during the entire project. This support was particularly useful during the beginning of the project when the students needed good experiences in mathematics in order to learn content and gain confidence. During the summer of 1986 three courses were taught. Hard-working, highly motivated participants and qualified, talented faculty produced twenty able secondary mathematics teachers through this project. These teachers will be productive in Texas mathematics classrooms for a long time. This project has been the beginning of an exciting journey in understanding, appreciating and learning to impart mathematics for these participants.

A PROGRAM TO PREPARE TEACHERS OF MATHEMATICS
Department of Mathematics, Computer Science
and Physics
Texas Woman's University
Denton, Texas 76204

A PROGRAM TO PREPARE TEACHERS OF MATHEMATICS

Dr. Rose Marie Smith, Chairman
Department of Mathematics, Computer Science and Physics
Texas Woman's University
Denton, Texas 76204
817-898-2166

The Department of Mathematics, Computer Science and Physics at Texas Woman's University has a long history of preparing mathematics teachers in the State of Texas. Currently, Texas is facing a severe shortage of competent mathematics teachers. There are, however, many teachers of other disciplines who have always had an interest in mathematics who find that investing in the task of learning mathematics has great potential for them. There are many opportunities in the geographical area around Denton, Texas, which includes the Dallas-Fort Worth area, for persons with ability, interest and credentials to teach mathematics.

The THA-MASTER provided a curriculum model very compatable to the curriculum used in the Department at TWU. After talking with Dr. Madeleine Long, the faculty at TWU were convinced that this was a project that would be successful at TWU. Their commitment to the project accounted for a great portion of the success we enjoyed.

Some of the students who attempted the project could not perform on the time line implemented. They had to work at a less challenging pace. In some instances they were unwilling or unable to achieve success at any pace. They, however, had tried and this was important.

Twenty students completed the project. They will be contributing to mathematics education for a long time to come. They are teaching in large systems and in small systems. Denton is on the northern edge of the Dallas-Fort Worth metroplex. We are surrounded by large urban settings and small rural communities and many setting in between.

This was a successful project for TWU. We are pleased to have been selected to be a part of what we believe is a very creative approach to preparing teachers of mathematics.

A Program to Prepare Teachers of Mathematics
Department of Mathematics, Computer Science and Physics
Texas Woman's University, Denton, Texas

FINAL BUDGET
July, 1985 - December, 1986

Salary for Site Director - Dr. Rose Marie Smith . 1/12 of contract amount for Fall and Spring semesters	$ 3,132
Salary for Administrative Assistant Graduate student for tutoring sessions Summer, Fall, 1985, Spring, Summer, 1986	7,333
Advertising for Recruiting Students	1,063
Operating Expenses including brochure, mailing, travel, supplies and duplicating	3,072
TOTAL	$14,600
Five hundred dollars ($500) was provided from the TWU site for the Dissimination Conference. One of the participants accompanied Dr. Smith to the Dissimination Conferencs.	500
Original Contract Total	$15,100

Texas Woman's University provided secretarial support and office space for the personnel involved in "A Program to Prepare Teachers of Mathematics" for the eighteen months of the project. In addition, the salaries for the teachers of record were paid by TWU. Indirect costs and fringe benefits were also contributed by TWU.

Amount of office support	$ 5,400
Amount of salary support	16,845
Amount of Fringe Benefits	2,970
Amount of Indirect Costs	1,200
TOTAL TWU SUPPORT	$26,415

Texas Woman's University announces

A Special Program to Prepare Teachers of Mathematics

In response to a critical need for mathematics teachers in public schools, Texas Woman's University is offering a special program to selected students to prepare as junior and senior high school mathematics teachers.

Here are some program highlights:

- Program begins during second summer session 1985 at TWU in Denton, official site of TIA MASTER program developed at Long Island University
- Unique course schedule and contact hour plan
- 18 semester credit hours in mathematics
- Lectures and small discussion groups
- Individual academic counseling and advising
- Opportunity to qualify for certification at the secondary level in mathematics
- Limited tuition scholarships available

To be eligible for this program you must be seeking secondary certification, recertification, or additional certification in mathematics as a teaching field; have completed one year of college mathematics; qualify for admission to the TWU Graduate School and/or the Certification Program. This program is open to qualified persons regardless of sex, race, creed, color, age, or national origin.

Please send me application and information about:

____ Program to Prepare Teachers in Mathematics
____ MA, MS, or MSEd degrees in Mathematics
____ Certification in Mathematics
____ I would like an appointment
(Phone 817 566-6335)

Name (please print)_____

Address _____

City _____ State _____ Zip _____

Phone: Business ( ) _____ Home ( )_____

For information, send this form to
Dr. Rose Marie Smith,
Site Project Director, TIA MASTER
Department of Mathematics, Computer Science, and Physics
Box 22865, Texas Woman's University
Denton, TX 76204, phone 817 566-6335

Texas Woman's University Denton

FY 1986 MATHEMATICS, SCIENCE AND COMPUTER SCIENCE
TEACHING IMPROVEMENT GRANT PROGRAM

FINAL REPORT SUMMARY FORM

86-992005-1800
(Contract Number)

Institution: Trenton State College

Project Title: A Program to Retrain Teachers in Mathematics

Date: February 15, 1987

Amount of Grant Award: $30,000

Amount Expended: $30,000 (unaudited)

Balance (unexpended funds): -0-

Major Accomplishments: The "Program to Retrain Teachers in Mathematics" was implemented as proposed. The program consisted of eight graduate courses designed to lead the project participants to certification in mathematics. Thirty-four individuals began the program and two more were added mid-stream. Of these, 19 completed the program and 22 either have or will receive certification. The project actually surpassed the original expectations in that when initially conceived the target population was 25 participants with a success rate of 60 percent predicted. The number of participants was increased to accommodate the Department of Education request for more teachers from urban districts.

The college wishes to thank the Department of Higher Education, the Department of Education, and Long Island University (FIPSE) for their support of this project. As a result the pool of prospective mathematics teachers within our state has increased substantially.

Number of Students Served or Project Participants:

(where appropriate) 36

Number of Course Affected

(where appropriate) 8

The program to Retrain Teachers in Mathematics was implemented as proposed. This final report offers an overview of the program accomplishments.

RATIONALE

At the time of initial discussion of the program, colleges in New Jersey were training very few students to teach mathematics in our schools. Additionally, there was a documented shortage of certified mathematics teachers, especially in urban districts. This program was designed to offer 24 semester hours of graduate credit which in conjunction with the 6 semester hours most participants brought to the program and with passage of the mathematics specialization test on the National Teacher Examination would lead to certification in mathematics. The original proposal targeted 25 participants and projected a success rate of 60 percent. Thus, it was assumed about 15 prospective mathematics teachers would be available for our schools.

SELECTION OF PARTICIPANTS

The participants in the program were selected from among the 94 applicants who applied. In order to attract applicants we utilized (1) mass mailing to each school in a five county surrounding area, (2) newspaper advertisements, (3) newspaper articles, (4) personal visits to area schools and county superintendent round tables, and (5) a special meeting for candidates as a result of a letter forwarded to districts from the Department of Education.

Of the 94 applicants approximately 70 were interviewed and 34 were selected to begin the program. All applicants who met the minimum qualifications for the program were interviewed. The final selection was made on the basis of merit with teachers currently teaching in urban districts given priority. As a result 16 of the 24 urban district candidates and 18 of the 46 non-urban district candidates were selected. For the record approximately 30 applications were not reviewed because they arrived after the deadline date. Also, about ten applicants requested mid-stream entry since they had already committed to other plans for Summer 1985. Overall, there were close to 200 requests for information about the program.

PROGRAM DESCRIPTION

The program offered an undergraduate refresher course plus eight graduate level mathematics courses over eighteen months. The timetable of the course offerings is given below:

Term		Courses Number and Title		Credits
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		MAT 510	Survey of Mathematics	3
Fall 1985,	Q1	MAT 512	Applied Calculus I	3
	Q2	MAT 514	Applied Calculus II	3
Spring 1986,	Q3	MAT 516	Introduction to Modern Mathematics	3
	Q4	MAT 695	Topics in Mathematics	3
Summer 1986		MAT 530	Geometry	3
Fall 1886	Q1	MAT 560	Linear Algebra I	3
	Q2	CSC 520	Fundamentals of Computer Programming	3

Participants were held to high standards in all courses. The program offered the students a strong foundation in mathematics and prepared them to be effective classroom teachers. The course description for each of the course offerings follows:

MAT 100 Refresher Mathematics for Teachers

Review of the essential topics and techniques of high school algebra and geometry.

MAT 510 Survey of Mathematics

Introduction to analytic geometry. Relations and functions. Polynomial functions. Exponential functions. Logarithmic functions. Trigonometric functions. Elements of linear algebra. Elements of probability and statistics. Applications.

MAT 512 Applied Calculus I

The nature of the calculus. Historical introduction. Functions. Mathematical models. Limits. Continuity. Differentiation. Applications of the derivative. Limits of transcendental functions. The mean-value theorem. Limits involving indeterminate form. Applications.

MAT 514 Applied Calculus II

Antiderivatives. Fundamental techniques of integrations. The Riemann integral. Applications of the definite integral. Improper integrals. Approximate integration. Sequences and series. Uniform convergence. Power series. Functions of several variables limits and continuity. Partial derivatives. Extreme values. Expansion of functions of two variables into series. Applications.

MAT 516 Introduction to Modern Mathematics

Propositional calculus. Mathematical proof. Introduction to set theory. The real number system. Cardinal numbers. Denumerability. Complex numbers. The fundamental theorem of algebra. Introduction to number theory. Groups, rings and fields. Euclidean and non-Euclidean geometries. Elements of projective geometry. Introduction to topology. Applications.

MAT 530 Foundations of Geometry

Postulational methods are discussed and emphasized to give a conception of the structure of Euclidean and non-Euclidean geometries. Elementary geometry is reexamined from an advanced point of view.

MAT 560 Linear Algebra I

A thorough treatment of linear transformations and their representation. Topics include matrices, bilinear forms, eigenvalues, eigenvectors, normal forms, vector spaces, and applications.

MAT 695 Selected Topics in Mathematics for the Secondary School Teacher

This course includes specific topics relevant to the secondary school teacher of mathematics. In particular, Number Theory is the focus of this course. Discussion centers on divisibility, prime numbers, unique factorization, quadratic reciprocity, sums of squares, and arithmetic functions.

CSC 520 Fundamentals of Computer Programming

A first course in computer programming for graduate students with a sophisticated mathematical background. An algorithmic computer programming language such as Turbo PASCAL will be taught assuming no prior knowledge, and used to program computational solutions of mathematical problems.

PROGRAM RESULTS

APPENDIX A of this report gives the student performance record of each of the participants in the program. A concluding statement indicates the reason for non-completion of the program where appropriate. Below is a table of the grade distribution for each course:

	A	B	C	D	F	P	WD	TOTAL
MAT 100	0	0	0	0	0	33	1	34
MAT 510	14	8	4	3	4	0	0	33
MAT 512	10	5	8	2	0	0	5	30
MAT 514	10	4	7	2	1	0	1	25
MAT 516	11	11	2	0	0	0	0	24
MAT 695	10	8	4	0	2	0	0	24
MAT 530	13	6	2	1	0	0	0	22
MAT 560	3	9	3	4	0	0	0	19
CSC 520	8	3	4	3	0	0	1	19

As a result of the program we assume at least 22 of the participants will receive certification in mathematics. Obviously the nineteen who finished the program either have or will seek certification. The three students who completed the program after Summer 1986 (six courses) all brought 12 credits to the program and either are certified or are seeking certification. In addition we know of at least one other that dropped out before the Summer of 1986 who has continued taking mathematics courses on her own which will eventually lead to certification. Of the three who are already certified, two of them are currently teaching mathematics for the first time. Several others have indicated that mathematics positions are available to them once they receive their certification. A follow up of each of the participants will be taken in the fall of the year.

Summary and Conclusion

In general, we were very pleased with the efforts of the participants. They were totally committed for eighteen months at great personal sacrifice. These individuals gave up two summers, one academic year, and one additional semester, as they traveled to Trenton State College twice a week to meet from 5:00-9:30 p.m. at the same time they were teaching full schedules during the day. The other nights and weekends they worked outside of class on their assignments. It was obviously a hardship for some, but they managed with strong family support in some cases and almost no family support in others. Only the most dedicated individual could survive such a gruelling schedule.

In order to receive feedback from the participants we continually requested and received faculty, course, and program evaluations from the participants. A sampling of the program evaluations is given in APPENDIX B. As you will note the feedback was mostly positive and reflected the efforts of those involved in the project. As a result we were encouraged to apply for a CYCLE II of this program and will soon apply for a CYCLE III.

It is obvious from reading this report that we believe the program has accomplished its major objective of providing the mathematics training to prepare the participants for service as mathematics teachers in our state. We further believe that this has been accomplished while maintaining high academic students and providing high quality courses. Obviously, as with any program, there were a few who did not achieve as well as others, but we still believe that they have a sufficient background to be quality teachers of mathematics.

Lastly, in APPENDIX C is a paper delivered by the Project Director at the Mathematics Retraining Conference in Puerto Rico in December. It indicates how the program offered meets NASDTEC Accreditation students.

PROGRAM TO RETRAIN TEACHERS IN MATHEMATICS
CYCLE I
PROJECT # 86-992005-1800
AMOUNT $30,000 - DHE
3,500 - LIU

Project Expenditures

			Adjusted Budget	Expended
I	Personnel			
	A. Directors's Stipend	- DHE	1500	1500
		- LIU	3500	3500
	B. Summer 85 Instruction			
	Instructor		3200	3200
	Associate		1600	1600
	C. Fall 85 Instruction			
	Instructor		2000	2100
Q1	Associate		1000	1050
	Instructor		2000	2100
Q2	Associate		1000	1050
	D. Spring 86 Instruction			
	Instructor		2000	2100
Q3	Associate		1000	625
	Instructor		2000	2100
Q4	Associate		1000	1050
	E. Summer 86 Instruction			
	Instructor		2000	2000
	Associate		1000	1000
	F. Fall 86 Instruction			
	Instructor		2000	2100
Q1	Associate		1000	625
	Instructor		2000	2100
Q2	Associate		1000	625
	SUBTOTAL	DHE	27300	26925
		LIU	3500	3500
II	Non-personnel			
	A. Supplies & Cert. Ceremony		2700	2700
	TOTAL	DHE	30,000	30,000
		LIU	3,500	3,500

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TRENTON STATE COLLEGE

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Sites for the THA-MASTER have been established at the following colleges and universities:

THA-MASTER DISSEMINATION SITES

Dr. Michael A. Iannone
Department of Mathematics and Computer Science
Trenton State College
Hillwood Lakes CN 550
Ewing Township, NJ 08625-0550
(609) 771-2269

Beaver College
Dr. A. Richard Polis
Office of Graduate Studies
Glenside, PA 19038
(215) 572-2960

The University of Miami
Dr. Gilbert A. Cuevas
School of Education and the Allied Health Sciences
Miami, Florida 33124
(305) 284-4301

Arizona State University
Dr. Lehi T. Smith
Dept. of Mathematics
Tempe, Arizona 85287
(602) 965-3951

Liu/Brooklyn Center
Madeleine J. Long
Project Director
University Plaza
Brooklyn, New York 11201
(212) 403-1056

Texas Woman's University
Dr. Rose Marie Smith
Dept. of Mathematics
Denton, Texas 76204
(817) 566-6335

University of Northern Colorado
Dr. Paul A. Lightsey
Dept. of Physics
Greeley, Colorado 80639
(303) 351-2961

Western Oregon State College
Dr. Robert Main
Division of Natural Sciences and Mathematics
Monmouth, Oregon 97361
(503) 838-1220 ext. 443

Please send an application and additional information for the Mathematics Retraining Program.

Please print

Name _____

Address _____

City _____ State _____ Zip _____

Telephone _____ _____
home business

252

Department of Mathematics
Trenton State College
Hillwood Lakes CN 550
Ewing Township, New Jersey 08625

A Program to Retrain Teachers in Mathematics

Trenton State College

Department of Mathematics and Computer Science

Using
Long Island University's
Model Mathematics Retraining Program
THA-MASTER
FIPSE FUNDED

TSC

253

A Program to Retrain Teachers in Mathematics

At the present time and in the near future there is a need for more certified teachers in mathematics. This program is designed to train non-mathematics teachers in the field of mathematics and to provide certification upon successful completion of the program.

PROGRAM HIGHLIGHTS FOR PARTICIPANTS

- Tuition free
- Graduate courses specifically designed for non-mathematics majors
- Two week refresher course will be offered Summer 1985
- Summer courses will meet for six weeks, 16 sessions, four hours per session.
- All other courses will meet twice a week, four hours per session, for an eight week period.
- One-half of each session will be the traditional classroom lecture — The other half will be a laboratory setting including individual tutorials, discussion groups, problem solving sessions and testing.
- 24 credits in mathematics will be offered
- Five of the courses will count toward the Master Degree in Mathematics offered by the Department
- Completion of all course work required for certification by December 1986 (full certification requires completing successfully the National Teacher Examination)
- Provides the opportunity for employment as a mathematics teacher.

ADMISSION REQUIREMENTS

- Certification in a field other than mathematics
- Classroom Teaching Experience
- Completion of at least six credits of college mathematics
- Interview with Project Director or Designee

STAFF

Site Project Director:
Michael A. Iannone, Ed.D.
Associate Professor and Department Chairman

Associate Site Project Director:
David Boliver, Ed.D.
Associate Professor of Mathematics and Computer Science.

OTHER STAFF INCLUDES:

Edward Conjura, Ph.D.
Professor of Mathematics and Computer Science

Charles Goldberg, Ph.D.
Professor of Mathematics and Computer Science

Jane Ann McLaughlin, Ed.D.
Professor of Mathematics and Computer Science

Siegfried Haenisch, Ed.D.
Professor of Mathematics and Computer Science

PROGRAM SCHEDULE

Summer 1985

MAT 100 Refresher Mathematics for Teachers
MAT 510 Survey of Mathematics

Fall 1985

MAT 512 Applied Calculus I
MAT 514 Applied Calculus II

Spring 1985

MAT 516 Introduction to Modern Mathematics
MAT 695 Topics in Mathematics for Secondary Teachers

Summer 1986

MAT 530 Foundations of Geometry

Fall 1986

MAT 560 Linear Algebra I
CSC 520 Fundamentals of Computer Programming

Trenton State College admits qualified students of any age, race, color, national or ethnic origins, or handicapped as defined by law.

FY 1986 MATHEMATICS, SCIENCE AND COMPUTER SCIENCE
TEACHING IMPROVEMENT GRANT PROGRAM

FINAL REPORT SUMMARY FORM

86-992005-1800
(Contract Number)

Institution: Trenton State College

Project Title: A Program to Retrain Teachers in Mathematics

Date: February 15, 1987

Amount of Grant Award: $30,000

Amount Expended: $30,000 (unaudited)

Balance (unexpended funds): -0-

Major Accomplishments: The "Program to Retrain Teachers in Mathematics" was implemented as proposed. The program consisted of eight graduate courses designed to lead the project participants to certification in mathematics. Thirty-four individuals began the program and two more were added mid-stream. Of these, 19 completed the program and 22 either have or will receive certification. The project actually surpassed the original expectations in that when initially conceived the target population was 25 participants with a success rate of 60 percent predicted. The number of participants was increased to accommodate the Department of Education request for more teachers from urban districts.

The college wishes to thank the Department of Higher Education, the Department of Education, and Long Island University (FIPSE) for their support of this project. As a result the pool of prospective mathematics teachers within our state has increased substantially.

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(where appropriate) 36

Number of Course Affected

(where appropriate) 8

The program to Retrain Teachers in Mathematics was implemented as proposed. This final report offers an overview of the program accomplishments.

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At the time of initial discussion of the program, colleges in New Jersey were training very few students to teach mathematics in our schools. Additionally, there was a documented shortage of certified mathematics teachers, especially in urban districts. This program was designed to offer 24 semester hours of graduate credit which in conjunction with the 6 semester hours most participants brought to the program and with passage of the mathematics specialization test on the National Teacher Examination would lead to certification in mathematics. The original proposal targeted 25 participants and projected a success rate of 60 percent. Thus, it was assumed about 15 prospective mathematics teachers would be available for our schools.

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CYCLE I
PROJECT # 86-992005-1800
AMOUNT $30,000 - DHE
3,500 - LIU

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	Instructor		2000	2100
	Q1 Associate		1000	1050
	Instructor		2000	2100
	Q2 Associate		1000	1050
	D. Spring 86 Instruction			
	Instructor		2000	2100
	Q3 Associate		1000	625
	Instructor		2000	2100
	Q4 Associate		1000	1050
	E. Summer 86 Instruction			
	Instructor		2000	2000
	Associate		1000	1000
	F. Fall 86 Instruction			
	Instructor		2000	2100
	Q1 Associate		1000	625
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		LIU	3500	3500
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	A. Supplies & Cert. Ceremony		2700	2700
	TOTAL	DHE	30,000	30,000
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WESTERN OREGON STATE COLLEGE

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THA-MASTER DISSEMINATION SITES

Long Island University
Dr. Madeleine J. Long
One University Plaza
Brooklyn, N.Y. 11201

Beaver College
Dr. A. Richard Polis
Easton and Church Roads
Glenside, PA 10938

University of Miami
Dr. Gilbert J. Cuevas
P.O. Box 248605
Miami, FA 33124

Arizona State University
Dr. Lehi T. Smith
Department of Mathematics
Tempe, AZ 85287

Texas Woman's University
Dr. Rose Marie Smith
P.O. Box 22865 TWU Station
Denton, TX 76204

University of Northern Colorado
Dr. Paul Lightsey
Department of Physics
Greeley, CO 80639

Western Oregon State College
Dr. Robert Main
345 Monmouth Avenue N.
Monmouth, OR 97361

Trenton State College
Dr. Michael Iannone
Hillwood Lakes CN 550
Trenton, NJ 08625

Division of Continuing Education
and Summer Programs
Western Oregon State College
Monmouth, Oregon 97361

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Monmouth, OR
97361

WESTERN OREGON STATE COLLEGE

Summer 1985

MATHEMATICS CERTIFICATION INSTITUTE

June 24-August 1

A Model Program to Retrain Teachers
to Teach Mathematics

THA-MASTER

Funded by

The Fund for the Improvement of
Post-Secondary Education
(FIPSE)

Developed by Long Island University

PURPOSE - to train skilled and experienced teachers who are certified in other disciplines to help fill the gap created by the expanding demand for mathematics instruction.

PROGRAM HIGHLIGHTS

Graduate courses

Unique course schedule

Regional video presentation of course content.

23 credit hours in the FIPSE program leading to math certification plus 6 credit hours meeting state certification requirements. *These requirements are met by taking Mth 444, 447 and 490 (or 491-3) plus 2 methods courses. (Note: The calculus course presumes sufficient algebraic and trigonometric background)*

Opportunity to utilize the course work in a Master of Science program

STAFF

Project Director: Dr. Robert Main

Dr. Beryl Green

Dr. James Barnard

Other Staff members to be announced.

TUITION FOR SUMMER

	3 credits	6 credits
Undergraduate	$139	$244
Graduate	$214	$394

ADMISSION AND REQUIREMENTS

* Contact the Admissions Office for general admission requirements and to receive application forms. (503) 838-1220, ext. 211.
* Contact Dr. Robert Main, Program Director, for a list of program requirements, ext. 443.
* Contact Graduate Office, for a list of Procedures for Graduate study, ext. 492.

SUMMER 1985 SCHEDULE

Mth 407G Mathematics for Middle School
Mth 407G Problem Solving for Teachers
Mth 407G Survey of Math (FIPSE)
Mth 444G Refresher Math-Geometry (FIPSE)
Mth 445G Advanced Concepts of Geometry for Teachers
Mth 447G Selected Topics - Algebra
Mth 448G Advanced Concepts of Algebra for Teachers
Mth 490G Concepts of Calculus for Teachers

ACADEMIC YEAR 1985/86 SCHEDULE

Applied Calculus I (FIPSE)
Applied Calculus II (FIPSE)
Applied Calculus III (FIPSE)

All of the mathematics courses listed are 3 quarter hours of college credit except Mth 407G Survey of Math which is 4 hours.

(The courses listed in the 1985/86 academic year schedule will be available throughout the region through Western's Instant Replay program.)

MATHEMATICS CERTIFICATION INSTITUTE - SUMMER 1985
Course Reservation Form

Name _____ Phone _____

Address _____
Street/PO City State Zip Code

Please reserve a place in the following courses (check boxes):

☐☐☐☐ Mth 407G Math for Middle School
☐☐☐☐ Mth 407G Problem Solving for Teachers
☐☐☐☐ Mth 407G Survey of Math
☐☐☐☐ Mth 444G Refresher Math - Geometry
☐☐☐☐ Mth 445G Advanced Concepts of Geometry
☐☐☐☐ Mth 447G Selected Topics - Algebra
☐☐☐☐ Mth 448G Advanced Concepts of Algebra
☐☐☐☐ Mth 490G Concepts of Calculus for Teachers

This form reserves a place in the course(s) you indicated but it does not officially register you in these courses. Upon receipt of this form, you will be sent pre-registration materials.

Please enclose a $20 deposit with the reservation form. Deposit applies to tuition. Balance due at registration. Make check payable to Western Oregon State College.

Mail to: **Math Certification Institute**
Division of Continuing Education
and Summer Programs
Western Oregon State College
Monmouth, Oregon 97361

☐ Please send housing information

At least 12 students are needed for a class to be offered. Classes will be limited to 30 students.

FINAL REPORT FIPSE SUPPORTED MATHEMATICS CERTIFICATION INSTITUTION

Mathematics Certification Institute-THA-Master Program
Western Oregon State College
Monmouth, Oregon 97361
Project Director: Robert Main, Ph.D.

FINAL REPORT FIPSE SUPPORTED MATHEMATICS CERTIFICATION INSTITUTION

PROJECT SUMMARY

The THA-Master Program became part of the ongoing Mathematics Certification Institute at Western Oregon State College during the summer of 1985. We have served 59 students in the last two years. The THA-Master courses were utilized as part of the Oregon Certification requirements for Basic Mathematics Certification and to enhance our academic offerings.

A particular dimension of the program which is of special interest is the utilization of video-tapes to teach calculus to students located in rural areas. Western Oregon's Division of Continuing Education has a program called "Instant Replay". This program is actually a logistical-delivery system for presentation of video-taped classes from the campus to various sites throughout the state. We utilized the Instant Replay system and the ITV Calculus course, developed by the Maryland Department of Education, to instruct our students at two regional sites. At these centers tutors were hired to meet with the students on a weekly basis and to provide the tutorial support needed. The tapes were also used during the past summer on campus for instruction in calculus.

Mathematics Certification Institute-THA-Master Program
Western Oregon State College
Monmouth, Oregon 97361
Project Director: Robert Main, Ph.D.
Phone: 503 838-1220, ext 443
Home Phone: 503 838-2883

BACKGROUND AND OVERVIEW

The Mathematics Certification Institute was started in response to the demand by teachers from other disciplines to gain certification in Mathematics. This demand was caused by: 1) an increase in the mathematics high school graduation requirements and a greater emphasis upon mathematics in Oregon, 2) a tightening of the certification requirements in the state and 3) restricted budgets in many districts forcing teachers in low demand areas or newly hired teachers to try and strengthen their credentials.

Initially the offerings were bare-bones but the program grew until in 1984 we were able to offer a minimal set of courses meeting the Basic Mathematics Certification requirements. The FIPSE grant-THA-Master Program allowed us to enhance the course offerings and take our students further academically. We were also able to initiate a video-taped calculus course which we offered at regional sites. This course will be discussed in detail later.

The funding of the Institute was primarily through the tuition of the participants with roughly 20-30% coming from FIPSE. The FIPSE funds primarily supported the video-taped calculus program including the regional tutors.

PROJECT RESULTS

During the last two years, 59 teachers, certified in other disciplines, have participated in the FIPSE supported THA-Master Program as part of the Mathematics Certification Institute and Instant Replay program at Western Oregon State College. Of these, 29 have attained Basic Mathematics Certification, and 3 have attained Advanced Mathematics Certification. There are 27 students who have either completed the requirements for Basic Mathematics Certification or are close to completion but for one reason or another have chosen not to request certification. (The requirements for certification at this level will change on January 15, 1987. Calculus will be deleted while computer science and theory of arithmetic will be added. Several of these students are waiting until the changes take place before applying for certification.) An additional 8-10 undergraduate students have opted to take one or more of the institute courses. At least one student, after starting in the THA-Master Program chose to attend school full time during the academic year in order to attain Advanced Mathematics Certification. See the Appendix for additional information on the individual students.

As can be seen in the Appendix, many of the participants were previously teaching under a missassignment. (Missassignments are allowed under Oregon law as long as each is less than 1/2 of the teaching assignment and requires no training in the discipline in which the missassignment occurs. However, quite often those teaching under a missassignment will have some training in the discipline.) One obvious conclusion is that the THA-Master Program and our Mathematics Certification Institute in general have had immediate impact upon the classes taught by these teachers.

The impact of additional training is amplified in rural areas where the math staff is small and they must cover a wide range of course offerings.

An example, not necessarily typical, is Prineville, Oregon. One of our participants, Terry Sime, teaches Math in the Prineville High School. During the last two summers and intervening academic year, he has attained Advanced Mathematics Certification. During the academic year he took the video-taped calculus course, and last summer he took two additional classes beyond those of the Institute. Prineville has 4 mathematics teachers in the high school and 3 in the middle school. There are 720 students in the school, some of whom live as far as 55 miles away. It is obvious that the upgrading of one teacher, both in terms of his understanding of the subject matter and of his enthusiasm, can have tremendous impact in a rural (cattle ranching) setting. The major impact of the program is that additional certified teachers have been provided to the state of Oregon.

We have established that inservice training can be delivered to teachers in remote areas through the use of video-tapes. We utilized the ITV Calculus program produced by the Maryland State Department of Education. The tapes were distributed to regional centers of Western Oregon's Division of Continuing Education Instant Replay network. The Instant Replay system was devised at Western as a means of providing inservice training to students located in rural Oregon by video taping on campus courses and disseminating the tapes to about 50 sites throughout the state. Nine students participated in the program for 1/2 of the course. (This is sufficient for the lowest level of certification in mathematics.) Three students completed the entire calculus course, two of whom have attained Advanced Mathematics Certification. These students worked at two sites: Salem and Bend, Oregon; some of them commuted 30-40 miles once or twice a week for viewing the tapes, picking up copies of the tapes and group tutorial sessions. The tutorial sessions were crucial to the successful completion of the course; therefore, the choice of tutors for these sites was of crucial importance. The test evaluation was done on campus, but the testing was done at the sites. A second crucial factor was having a small group of students at each site to work with the tutors. We tried to have two students work individually with the aid of a local tutor and the tapes. This proved to be unsuccessful; neither of the students was able to complete the work. The small group seemed to aid in the feedback process necessary for learning as well as for providing a social support system. (For further details on the video-taped part of our program see "PRESENTATION OF CALCULUS TO RURAL AREAS THROUGH THE USE OF VIDEO-TAPE" by Dr. Robert Main.)

LIMITATIONS

The certification requirements in Oregon are very prescriptive. For example, in order for a student to attain the Basic Mathematics Certification, he or she must have had two math methods classes plus demonstrate competencies in geometry, algebra, computer science and the theory of arithmetic, with the exact nature of each course being left to the institution. (Previously, calculus was included; it has been replaced by the computer and the arithmetic requirements.) The number of term hours is to be approximately 21. The net result is that many of the participants in the THA-Master Program were not interested in completing the program. Their major goal was to attain certification by taking only those classes which were required. Hence, Refresher Geometry averaged 30 students per summer while the total enrollment in the Calculus classes during both summers and the academic year was about 20.

Superimposed upon this problem were fiscal problems of the students and the institution. Oregon has yet to fully recover from the recession, and jobs were uppermost in most participant's minds. Similarly, the minimal class size was limited because all of the summer programs in Oregon receive no state funding. This caused us to drop two of the classes last summer due to insufficient preregistration figures, but neither of these classes were required for certification.

The other side of the certification coin in Oregon is that many areas require mathematics, so that students coming to us often had the prerequisite skills and did not need the introductory course. For example, every elementary teacher must have a minimum of 4 terms of math coursework prior to certification.

Finally, the Calculus video-taped course needs renovation to bring it into line with the THA-Master philosophy and the needs of teach training. The current course has more of an engineering-physics flavor. Work also should be done so that it is more independent of the on-site tutor. An additional workbook and supplementary tapes should be produced to accomplish this goal.

SPECIAL CONCLUSIONS

Two positive spinoffs that have resulted from the THA-Master program are:

1. We were able to offer courses which, in the past, would not have been offered due to low enrollment. This was because the FIPSE funds supported the THA-Master courses, and there was a larger pool of students who had the necessary prerequisites for the class.

2. We plan to add one or more courses from the THA-Master Program to our list of permanent graduate offerings, making them available to all our graduate students. The Introduction to Modern Mathematics course, in particular, has the potential to become an excellent class for all our graduate students.

FUTURE DIRECTIONS

1. Western Oregon intends to continue the Mathematics Certification Institute through at least the summer of 1988. We are beginning to offer intermediate level coursework, which will help the participants of previous summers bridge the gap between Basic Mathematics Certification and Advanced Mathematics Certification.

2. We are considering reworking the video-taped calculus course in the manner described above. Additional tapes and a workbook would be produced. We are also considering offering other courses through the instant replay format (video-taped), which are required for certification.

FINAL CONCLUSIONS

The great strength of the THA-Master Program (and it Director, Dr. Long), is it adaptability to a variety of settings. Oregon with its stringent certification requirements and rural setting is quite different from Long Island, New York or Dallas, Texas. Because of the prescriptive certification requirements, our students came to us better prepared than those at many of

the other sites. On the other hand to meet these state requirements the content of several of the THA-Master courses had to be modified. Without the flexability to modify the program without changing its basic character and goals we would have not been able to accept the FIPSE grant. Through the THA-Master Program we have been able to meet a greater variety of re-training needs.

A second strength of the program should be mentioned; the opportunity to share ideas and problems with the other site directors. This network enabled me to share with my colleagues here at Western Oregon the solutions and potential pitfalls found at other institutions, thus facilitating the development of our own program.

FINAL REPORT FIPSE SUPPORTED MATHEMATICS
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GENERAL CONCLUSIONS

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